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THE EMPEROR FREDERICK'S MONUMENT AT WORTH.—DESIGNED BY BAUMBACH.

### THE EMPEROR FREDERICK MONUMENT AT WÖRTH.

On the battlefield of Wörth, where the confederation of the Northern and Southern German states was sealed with blood, now stands a monument erected to the memory of Emperor Frederick, who on that day—as Crown Prince Frederick William—led his troops to victory. This monument, which was unveiled on October 18, is not only a worthy tribute of the people to their beloved Prince but also, in a sense, a renewal of the oath of allegiance to the Bund uniting the German races. The work, which was so happily designed, has been most artistically carried out.

With a true appreciation of the task put upon him, and considering that the statue was to be erected in the open country, not among the edifices of a city, the sculptor, Max Baumbach, gave up the idea of the usual architectural pedestal and substituted for it a mass of rough hewn red sandstone upon which the lofty steed, controlled by the firm hand of the prince, seems to have sprung, so that the commander might the better watch and direct the shifting scene of battle. But this rock, which raises the rider high above all surroundings, also symbolizes an altar on which two emblematic figures swear allegiance to the Bund, and near them are the eagle and the lion, the emblems of Prussia and Bavaria, the leading races of the North and the South; while the coat of arms of Alsace-Lorraine, which is cut in the rock above their heads, reminds us of the object of the confederation and what was gained by the struggle. Although at first the whole may appear unartistic, the eye gradually becomes accustomed to its great proportions and appreciates the real harmony of all the parts, which tends to throw into relief the action of the figures of the prince and the horse. The terrace on which the monument stands is 11 feet 5 inches high, the rock 28 feet, the statue measures 18 feet 6 inches, and the figures on the pedestal, which are also of bronze and were cast in the Gladenbeck foundry, are 12 feet high.

This is the first great monumental work completed by Baumbach, who, years ago, became prominent among the young sculptors in Berlin. He was born November 28, 1859, at Wurzen, and received his first instruction in art at the Art Museum in Berlin. Later he studied under Schaper and Reinhold Beggs. In 1884 his original and independent talent asserted itself in the half figure of a "Jolly Drinker," and his three satyrs, which were placed in the Exhibition Park during the Greek Festival of the Berlin artists in 1886, are remarkable on account of the freedom with which the subject is handled and the delicious humor displayed. About the same time attention was attracted by his poetical sketch for a war monument with which he entered the career of a monumental sculptor. Since then he has produced many lifelike portrait busts and pleasing statuettes, and his group representing a mother praying with folded hands for her dying child is a masterpiece of modern ideal sculpture. While working on the monument for the battlefield of Wörth he had time only for a few excellent busts; but recently he has received a premium for his design for the Berlin monument of Bismarck. The vigor of his work seems to promise many more years for devotion to art.—*Illustrirte Zeitung.*

### RECENT IMPROVEMENTS IN THE SUGAR INDUSTRY.

By M. L. LINDET, Bull. de la Soc. d'Encouragement pour l'Ind. Nat., February, 1895.

In this paper a summary of new suggestions for processes in connection with the sugar industry is given in outline, special attention being devoted to those actually adopted.

I. Cleansing the Beetroot.—In many works this is commenced in the hydraulic transporters. These are canals lined with cement, constructed on an incline, and leading from different parts, where the beets are dug, to the washing building. The beets thrown in are carried along by a current of water and reach the washers freed from the largest part of the adhering soil. At the end of the canals they are from 1 to 1.5 meters below the surface, and some apparatus is therefore necessary to raise them. This may be easily effected by Maguin's wheel elevator.

In many places Loze's stone removing washer has been set up. It consists of a box containing water, into which the beets fall. A current of water from below drives them to the surface, where they are caught by a grating and removed, while the stones fall to the bottom.

The brushing and wiping machine of Denis Lefèvre is made use of in certain factories. In this the beets are rubbed by a series of rotary brushes while water runs over them.

Perforated drying tables actuated by a to and fro movement are often used to remove the water from the beets before weighing.

II. Diffusion.—(a.) Root Cutting.—The only important modification consists in the placing of a horizontal rotary brush above the knives, the object of which is to remove ligneous fiber.

(b.) Diffusion Battery.—These have not been modified. It is usually preferred to have them with lateral doors to discharge the exhausted roots, while the juice passes through a hole at the bottom. Rousseau Decker, in 1890, proposed having the two parts of the battery separate, but this appears now to have been abandoned.

(c.) Utilization of Spent Roots.—Desiccation of the spent roots has not found much favor among French manufacturers, although used in several German works. The furnace most generally used is that of Bittner & Meyer. This is of solid masonry and has four floors. The pressed roots fall on the top floor, and, pushed by agitators and shovels, travel over the other floors to the bottom. Simultaneously a mixture of hot air and coal gas enters at the top at 450°, and passes out through a ventilator at the bottom, removing the water vapor with it. One thousand kilos. of the dried roots produced represent an expenditure of 1,000 kilos. of coal.

In the Makensen furnace, which consists of three rotary cylinders, the gas and air also pass in the same direction as the roots, while in the Schulze & Schaerzel furnaces they pass in the opposite direction.

III. Purification of the Juice.—(a.) Filtration Before or After Dealbuminization.—The crude juice holds in suspension a certain amount of ligneous and pulpy matter. Many manufacturers consider mere filtration insufficient, and think it necessary to again filter the juice, after the albumen has been coagulated at 75°–80° C. This removal of albumen, first proposed by Possoz & Perier, in 1863, was again brought forward by Boury & Provins, in 1894. More recently, Bouvier has shown that when the juice is warmed with 1 per cent. of lime, there is real defecation. But juice thus treated does not appear to show a higher standard of purity than that submitted to carbonating without it.

The chief advantage consists in the removal of substances which would foul the heating tubes, and it is questionable whether the result is worth the trouble involved. There is, moreover, the additional disadvantage that the dealbuminized juice is very difficult to filter. To obviate this, Bouvier has devised a decantation filter, in which the suspended matter is retained by vegetable fiber placed in baskets, which can be replaced in the apparatus when clogged.

Daix & Bouchon have also proposed methods of filtration through cotton or woolen fiber, and even through coke. Quite recently Bouvier has suggested the removal of the coagulated albumen by making an emulsion of the liquid with oil, which, rising to the surface, carries the impurities with it.

(b.) Use of Anhydrous or Slaked Lime.—There has been much discussion of late as to whether any material advantage is gained by using these instead of milk of lime. Aulard recommends anhydrous and Mittelmann slaked lime. The addition of water in the milk of lime is avoided, and in the case of the less dense juices better extraction is possible, but whether there is a greater degree of purification is a moot point. In the removal of the lime from the sugar juice, the tendency of the latter to become caramelized by heat may be obviated by the use of Koenig's liming apparatus.

(c.) Carbonating Tanks.—Several manufacturers have constructed these deeper than those ordinarily employed, the object being to render the absorption of gas as complete as possible.

(d.) Continuous Carbonators.—In the exhibition of 1889 two kinds were exhibited. That of Horsin-Deon, which consists of a series of eight trays arranged as in a filter press, with compartments in which the carbon dioxide meets the limed juice; and that of Barbet, in the form of a cylindrical metal tank in which the juice enters from above and the gas from below. The Lucke carbonator and the Mollet-Fontaine carbonator are constructed on the same principle, while in the Reboux carbonator the limed juice passes upward through a series of zigzag brass tubes, the carbonic acid being introduced through concentric pipes. The working of these apparatus being difficult to regulate, they have not yet met with any general acceptance.

(e.) Double Carbonating.—French manufacturers are now in the habit of working denser juices than was formerly done.

(f.) Filtration from Scum.—Large filter presses have almost entirely replaced small filters, and those most generally used have a surface of a square meter. Last year an apparatus for continuous filtration was brought out by M. Droschout, which will probably be widely adopted.

(g.) Use of Baryta.—The purification of sugar juice by means of baryta was first tried by Manoury and afterward by Du Beaufret, but the results do not seem sufficiently satisfactory to lead to the general adoption of any of the processes.

(h.) Substitute for Carbonating.—Vivian & Lafranc have proposed a method in which the juice is treated with a mixture of fluosilicate of lead, ferrous fluosilicate, and ferric fluosilicate.

(i.) Replacement of Carbonating by Electric Purification.—Many experiments have been made since 1884 with the object of partially or completely replacing the process of carbonating, but up to the present time they have been more successful in the laboratory than in practical working.

(j.) Treatment of the Juice, Sirup, etc., with Sulphur Dioxide.—There is a general agreement that sulphur dioxide is a valuable purifying agent, but care must be taken to prevent the liquid becoming acid to any extent, lest inversion should take place. In certain cases, however, the point of neutrality may be safely passed, as where there are many organic salts present, the liberated organic acids not being so active in producing inversion as are the mineral acids.

(k.) Mechanical Filtration of the Juice and Sirup.—The necessity for rapid work has caused filtration through cotton tissues, known as Puvrez tissues, to be widely adopted. In most of the French factories these are used in mechanical filters, the liquids being forced through under pressure.

IV. Evaporation of the Juice.—(a.) Increasing the Power of Evaporating Apparatus.—The most notable improvement in this direction has been the introduction of apparatus in which the liquid does not fill the tubes, but only trickles over the sides. With this end in view various tubes à risselement have been constructed. These contain an inner concentric tube projecting a little from the top of the main tube. The liquid enters by apertures between the two tubes, trickles over the inner surface of the main tube, while the vapors escape by the center tube. This invention has not found much favor with manufacturers, who assert that they can attain the same result by partially filling the ordinary tubes.

(b.) Coolers.—With the object of avoiding mechanical loss many manufacturers attach metal boxes, known as Hodeck coolers, to their apparatus. The vapors pass through these before entering the condenser.

(c.) Barometrical Condensers.—Where water is abundant these are often advantageously introduced. They consist of a brass cylinder, where the vapors are condensed by a strong current of cold water. The hot water passes out by a conduit, and is carried away by a current of water from the weir.

(d.) Horizontal Evaporation Tanks.—Here the tubes are horizontal and the vapor circulates in the interior instead of the exterior. They have been adopted in several countries, but their superiority is not yet established.

(e.) Apparatus for Increasing the Rate of Evapora-

tion.—A most important modification has been the multiplication of the number of tanks and the utilization of the heat of the vapors formed on evaporating the juice. The saving of charcoal often amounts to as much as 30 per cent.

V. Boiling and Crystallization of the Sugar.—(a.) Boiling Apparatus.—In many factories the old cylindrical boilers have been replaced by rectangular ones surmounted by domes. These have the advantage of being capable of containing a large number of horizontal tubes, and thus giving an immense heating surface. Various modifications are in use. The Reboux boilers, in which the mass is kept in motion by mechanical agitators, insure the prevention of the formation of small crystals.

(b.) Methodical or Systematic Boiling.—The foreign matters which accumulate in the sirup surrounding the crystals do not interfere much until the liquid becomes too viscous to prevent the crystals being formed. M. Steffen has proposed a means of obviating this, by adding at this point sirup of equal purity and afterward of lesser purity, than the sirup inclosing the crystals. To be successful the work must be done very slowly, and the sirup added should previously be diluted to 25°–27° B. This system favors the growth of large crystals from the small ones.

(c.) Cooling the Boiled Mass and Crystallization in Motion.—With the object of increasing the size of the small crystals, Schutzenbach has suggested cooling in small portions of 100 kilos, in airy chambers, but in this method the cooling is not regular. A better process is to place the sirup in cylindrical boxes with an outer cooling jacket of water, and having within powerful agitators to keep the mass in motion. The Stammer-Bock apparatus has been widely adopted.

(d.) Modifications in the Work of the Second and Third Crystallizations.—A process has been introduced in which by crystallizing in motion and using sirup previously subjected to the turbine a great saving in the time of the second and third crystallizations is effected. Unfortunately the plant required is very expensive.

VI. Turbinage.—The chief problem has been to discover a method of continuous turbinage. The most successful attempts in this direction are the machines designed by Szezeniewski & Ponkowski, and those of Lizeray & Dumoulin, which give results so satisfactory as to lead to the hope of their being generally adopted.

Broadly speaking, the object of later improvements in the sugar industry has been to economize hand labor, animal charcoal, and general expenses. The last has been realized by making the various operations continuous, and the last by increasing the daily output and diminishing the number of days occupied in manufacture.—*Jour. of the Soc. of Chem. Ind.*

### DYEING AND COLORING PAPER.

By A. M. VILLOX.

VARNISHING with Metallic Soaps.—Metallic soaps form excellent varnishes for paper, because they are very adhesive, impermeable and flexible. As a base for these varnishes, palmitate of alumina may be taken as a type. An aqueous solution of palm soap is treated with sulphate of alumina. 10 kilos. of soap are dissolved in 100 kilos. of boiling water. 30 kilos. of sulphate of alumina are dissolved in 200 liters of boiling water to which is gradually added the soap solution, while agitating. A white gelatinous precipitate of palmitate of alumina is formed, which solidifies during the twelve hours the liquor is allowed to cool. This precipitate is placed upon a cloth to drain, pulverized, washed in cold water and dried. The agglomerated pieces are again reduced to powder. Palmitate of alumina is insoluble in cold water, but soluble in benzene, essence of turpentine and petroleum spirit. A solution of alumina soap of 35, 40 and 80 grammes per liter of petroleum spirit constitutes an excellent varnish for paper, which may also be employed like gum lac, than which it is much cheaper, and is also absolutely transparent. Another method of preparing this soap consists in dissolving 1 kilo. of soap in 10 liters of water, and gradually adding 15 liters of petroleum spirit, with constant stirring. The liquid finally separates into two layers, the lower being an aqueous solution of soda and the upper a solution of alumina soap in petroleum spirit, which is decanted off and allowed to rest a week until clear and free from water.

The coloring of varnish is a delicate operation, owing to the difficulty of preventing the destruction of the transparency. The coloring matter must be quite soluble in the vehicle employed. Until recent years there were only alcohol varnishes that were suitable for the production of colored varnishes, whereas these are now prepared from colored soaps, colored resins, waxes, etc.

Resins, dragon's blood and gamboge give the yellow and red varnishes; the gold alcohol varnishes are also prepared as described. The following are a few examples of gold varnish:

1. Gum lac, 500; eachou, 4; dragon's blood, 60, and alcohol 90°, 500 grammes.
2. Gum lac, 250; gamboge, 125; saffron, 10, and alcohol, 1,000 grammes.
3. Gum lac, 250; sandarac, 125; mastic drops, 70; Venice turpentine, 60; gamboge, 60; aloes, 15, and alcohol, 90°, 1,500 grammes.
4. Gum lac, 180; sandarac, 45; Venice turpentine, 48; dragon's blood, 125, and alcohol 90°, 1,500 grammes.

Varnishes colored with extracts of coloring matters are prepared by simply dissolving the coloring matter and then the resin in alcohol. Cochineal, indigo (indigo carmine), quercitron, orcheat and orchil can also be employed. For this class of varnish, vegetable coloring matters have been gradually replaced by artificial colors, which give brighter, clearer and "shot" colors.

Varnishes Tinted with Aniline Colors.—The ordinary varnishes are simply prepared by adding to the white transparent varnish an aqueous solution of aniline color in alcohol. This forms a beautiful varnish, but very fugitive in the light. The colors may be mixed to obtain any desired shade.

To produce fine solid colors for a fine varnish it is not desirable to use soap, resin or wax colors. The basic colors only should be used. Insoluble or slightly

soluble colors should be dissolved in alcohol, but if soluble in water, use that vehicle. Dissolve 30 grammes of Marseilles soap in 2 liters of water, then add the color, which is immediately precipitated as an insoluble soap. With methylene blue, the separation is instantaneous. With light blue the soap color remains partly in solution and partly in suspension in the water. In this case, facilitate precipitation of the color by addition of a little hydrochloric acid. The color is collected on the filter, washed with water, dried at a low heat, and spread on a porcelain plate.

To avoid filtration, agitate the liquid containing the precipitated color with some petroleum spirit or benzene. To produce the resin and wax colors, operate in the same manner, but in the place of Marseilles soap, use the soap obtained by boiling resin or wax with a solution of caustic soda. These aniline colors are soluble in alcohol, petroleum spirit, benzene, essence of terebenthine and carbon disulphide. Such colors may be employed for alcohol varnishes and also varnishes of palmitate of alumina, the colors obtained being very beautiful.

Varnishes Colored with Mineral Substances.—The alcohol varnishes can also be colored with Prussian blue (prussiate of iron free from alumina) and acetate of copper. The employment of successive layers of Prussian blue with gamboge or turmeric gives a wide range of shades. Blue with carmine varnish, with dragon's blood varnish, gives a range of violet shades.

The soaps of the metals in a solution of petroleum spirit or benzene, also give the solid shades, but unfortunately they are a little dull and short of luster, which might, however, be avoided by using aniline colors.

The following are the colors of the different soaps:

Soap of iron.....	Brown orange.
chromium.....	Violet shade of green.
copper.....	Malachite green.
nickel.....	Emerald green.
cobalt.....	Lilac.
uranium.....	Light yellow.
manganese.....	Rose.

These soaps are to be employed with palmitate of alumina.

Colored gelatin varnishes, varnishing with lacs, and the making of spangled paper, are next briefly described.—Bull. J. des Fab. de Papier, 1895.

#### ALUMINUM SOLDERS.\*

By JOSEPH RICHARDS.

VERY soon after Deville first made aluminum on a large scale, it was found that it was a most difficult problem to solder it satisfactorily. The ordinary alloys used for soldering were found not to attach themselves to aluminum, despite every usual precaution, and it was seen that unusual solders must be devised to meet this unusual problem. M. Christoffe, the goldsmith, of Paris, gave the subject his special attention, and discovered that aluminum was wetted by, and could therefore be soldered with, either pure zinc or pure tin. It is indeed true that both these metals hold firmly to the aluminum, but the zinc seam is brittle and crystalline, will not stand working, and discolors badly in a short time, while the tin seam has the disadvantage of disintegrating and falling to pieces in a few weeks. This latter phenomenon is due to the fact that certain alloys of tin and aluminum will decompose spontaneously by the action of the air. This is particularly true of tin containing small proportions of aluminum, up to 10 per cent.; for, if a bar of such alloy is left in the air, and portions are broken off at regular intervals, a change will be visible in the section, proceeding from the outside toward the center; and while at first the alloy is strong and tough, it gradually becomes more and more friable until at length, when the change has reached the center, it breaks like a pipe stem. I have observed a bar, one-sixteenth inch thick, to become decomposed all through in three weeks, and on thinner sections the effect is still more marked. Tin containing 0.5 per cent. of aluminum was rolled by a Philadelphia maker of tinfoil into foil, 0.001 inch thick, and, while it rolled beautifully, yet in two hours thereafter, the whole sheet was as brittle as glass. Now, bearing these facts in mind, it can easily be understood why a joint soldered with tin falls apart. The tin attaches itself to the aluminum by forming an alloy at the junction, and this alloy decomposes in a short time.

It would be a serious task to catalogue all the different metallic mixtures which have been proposed for soldering aluminum since M. Christoffe's experiments in 1855. Alloys of aluminum and zinc were tried by the Tissier Brothers, but were found to be too brittle. M. Hulot proposed to first plate the aluminum at the joint with copper, and to solder the coppered surfaces with ordinary solder.

At length the Société d'Encouragement offered a prize for a solution of this problem, which was awarded to Mourey, a Parisian goldsmith. His best solders were alloys of aluminum and zinc, to which small proportions of copper were added, to give them toughness. The chief difficulty with these solders is their high melting point; the zinc, which melts only at incipient red heat, being the most easily fusible ingredient.

For brazing and blowpipe work, such high melting alloys can be used, and the addition of a little silver improves them still more; but none of them can be regarded as convenient for use with the soldering iron.

It has been claimed that by using silver chloride as a flux, aluminum can be soldered in the ordinary way with ordinary tin solder; but this method has not proved satisfactory in practice, and, even if it were, the flux is too expensive.

Starting with a full understanding of the difficulties of the problem, and a knowledge of what had been previously tried and found wanting, I proceeded with the object of finding, if possible, a solder which should have the following qualifications:

- (1) It must wet the aluminum and adhere firmly.
- (2) It must not disintegrate after exposure to the air.
- (3) It must be as malleable and strong as aluminum.

\* Abstract of remarks made before the Franklin Institute.—From the Journal.

(4) It must have a low melting point, so as to be easily worked with a soldering iron.

(5) It must have the same color as aluminum, and not change color; and

(6) It must be cheap enough for general use.

After experimenting about two years, it was finally found that an alloy of zinc and tin in certain proportions, containing a little aluminum and some phosphorus, realized almost every qualification. The alloy used for some time was made by fusing together:

	Parts.
Aluminum.....	1
Ten per cent. phosphor tin.....	1
Zinc.....	8
Tin.....	32

It was found, however, that, on remelting this solder, a more fusible alloy liquated away from it. It appeared reasonable to assume that this more fusible part was a true alloy of zinc and tin, and, therefore, a more stable compound. This fusible portion was also found to solder better than the original mixture. This liquated solder was therefore analyzed, with the result that its composition was found to be very close to that expressed by the formula  $\text{Sn}_2\text{Zn}_3$ . The solder which I now use is made to correspond closely to this formula. It is obtained by using the ingredients in the proportions 1, 1, 11, 20, instead of 1, 1, 8, 32, as previously described. The percentage composition of the several alloys described may be thus compared:

	Original solder.	Found in the liquated alloy.	The formula $\text{Sn}_2\text{Zn}_3$ calls for	Solder, as now made, contains
Aluminum ..	2.38	—	—	2.26; Zinc + aluminum,
Zinc ..	19.94	—	29.8	26.19; 36.97 per cent.
Tin ..	78.34	71.65	70.7	71.19
Phosphorus ..	0.34	—	—	0.34

The percentage of zinc in the new solder is lower than called for by the formula  $\text{Sn}_2\text{Zn}_3$ ; but since aluminum and zinc are metals having many physical analogies, it was thought advisable to bring the combined percentage of these up to that required for the zinc alone. Further, as the tin is most liable to lose by oxidation during the mixing of the solder, it was thought best to have it slightly in excess.

The result of these investigations is before you in the specimens of soldering presented for your inspection. As practical usefulness is a fair criterion of the value of an invention, I may be permitted to mention that this solder has come largely into use in Germany, Switzerland, England and our own country.

It must be remembered that at present the demand for an aluminum solder is limited. About 4 tons of aluminum are now produced daily in the world, but fully 75 per cent. of this is used up in the steel industry and in making alloys; while of the remaining 25 per cent. which is rolled, spun, cast, or stamped into pure aluminum articles, probably not 10 per cent. is in such shape as to require soldering. Assuming, then, an average of 200 pounds a day of aluminum articles to be soldered, a daily supply of a very few pounds of solder would meet the entire demand.

It does not require the prophetic eye, however, to see that the 1,000 tons of aluminum produced during 1893 will probably reach 10,000 tons a year within the next ten years, and that with increased production the demand for a good solder must correspondingly increase.

In conclusion, I wish to add that I am indebted to my son, Dr. J. W. Richards, of Lehigh University, for chemical analyses and other aid in preparing this solder.

#### ON THE GROWTH AND SUSTAINING POWER OF ICE.\*

By P. VIDEL, C.E., M. West. Soc. Eng.

WHEN, in the fall, the temperature of the air decreases, the water gets gradually cooled off from the surface. The colder surface water sinks and the warmer water from below rises, gets cooled off at the surface and sinks again to let some relatively warmer water from below rise in its turn, and so on continually, as long as the colder water has a greater specific gravity than the warmer. So far, this process of cooling off from the upper surface is parallel to the heating of the water in a boiler by a similar circulation from the under surface. But it is known that water, unlike any other fluid, has its maximum density at a certain temperature, and expands from that point whether the temperature decreases or increases. For pure, fresh water, the specific gravity increases from 1 at 62° F. to its maximum 1.00112 at 39.2° F. (4° C.); for sea water, the corresponding temperature is 25.3°–27° F. When, therefore, the surface water is cooled off to 39.2° F., it sinks, not to rise again unless either heat or cold is conveyed to it at the bottom. The water which has taken its place at the surface sinks, to remain below at that same temperature, and, consequently, when the whole water body is cooled down to 39.2° F., all circulation stops. The only way in which the water can then be further cooled off from the surface is by conduction, but the conductivity of water being small, this is a very slow process compared with the former.

When the temperature of the surface layer reaches 32° F., ice is generally formed in fresh water; the freezing point of sea water is at 27°–28° F. But rapid running streams may not be ice-bound at much lower temperatures, and in perfectly calm water the temperature may go down considerably, perhaps 10°–12° below the freezing point, before the formation of ice, which then takes place suddenly by the slightest motion, caused, for instance, by a gust of wind or the introduction of an ice crystal. The heat of liquefaction, being set free, raises the temperature of the ice to 32° F., but immediately after, its upper surface partakes of the variations of the temperature of the air. The ice cover protects the water from agitation by winds and from further cooling, inasmuch as the heat from the water now has to be conveyed the greater distance,

through ice and through snow, which may have fallen upon it.

But the bottom of a lake or a river, if not too shallow, has a temperature corresponding to that of the earth crust at the same depth. At 6½ feet below the surface the annual mean temperature of the soil was 55° F., when that of the air was 50.4° F., and the extreme variations were respectively 24.7° and 84° F. At 50–60 feet depth the temperature is approximately uniform, 50°–60° F. in temperate climates and increasing about 1° F. for each additional 50–60 feet. But at less depth the temperature will change with the seasons, only so slowly that maximum below may be reached several months after the summer above. The bottom will then give off heat to the water nearest to it and currents may arise. Thus, the temperature may be 33° directly under the ice, 29° about 6 feet below, and 42° F. at the bottom, 25 feet below the surface. On the other hand, the average temperature of the water beneath the ice is sometimes found less than 39.2°, although the cold has not lasted long enough to have produced it by conduction only; thus in some of the Scottish lochs, temperatures of 34°–37°–38° F. have been measured. An explanation\* of this phenomenon is sought in differences in temperature of the air on different points of the lake. An ice fringe first being formed near shore, currents are produced by the different densities of the water under the ice and outside it, a surface current carrying water from shore toward the center of the lake, where it is cooled off by the air, and under-currents carrying it back toward shore. Also, at the bottom of open, running water, especially on shoals, the temperature may sink to, or—perhaps by radiation—below, that at the surface, and give rise to the formation of anchor or ground ice ("groundgru," "frozee"), the current at the bottom being retarded by the friction.

The specific gravity of ice lies between 0.90 and 0.95, and may as an average be taken as 0.92. In freezing, water therefore increases in volume from  $\frac{1}{4}$  to  $\frac{1}{2}$ , or as an average  $\frac{1}{3}$ ; and when floating, the ice will be immersed about  $\frac{1}{3}$ , while  $\frac{2}{3}$  of its mass will be above water. The formation of ice is, perhaps, rather an intermittent than a continuous process; but it seems to be proved that the growth always is downward, due to the freezing of the water under the ice, and not of vapors condensed on its upper surface. Still, such vapors escaping through or from the ice, or the so-called "frost smoke," may produce those beautiful hexagonal stellate crystals, or six-leaved ice flowers, which in cold weather are sometimes found on its surface. And when by a rise of the river the ice sheet is held down by its sides, and thus, or by rain or melting snow, or in any other way, its surface becomes covered with water, then a subsequent frost will, of course, increase its thickness by a growth upward. But such growth, being accidental and due to particular, incalculable circumstances, may here be left out of consideration.

The rate at which the ice is formed and grows depends upon the temperature of the air and the condition of the water, whether still or running, in a rock or mud bed, with or without springs in the bottom, salt or fresh, pure, or polluted with organic, putrescent matter. The specific gravities of ice and water, specific and latent heats, coefficients of conduction and radiation, etc., all influence the formation of ice.

The sudden disappearance of the ice on various lakes has often caused surprise. On Lake Champlain an expanse of ice 12 inches thick has been known to vanish during a single night. It has been found in such cases that the ice was transformed from a solid homogeneous mass into an aggregation of irregular, prismatic needles, placed vertically, close together, and with but a trifling cohesion to one another. This is the "penknife ice" which Captain Parry met with in the Arctic. The needles are perhaps  $\frac{1}{2}$  to 1½ inches broad in the middle, and 5 to 10 inches long, or as long as the ice sheet is thick. When first an open strip of water is formed, these needles, either by themselves or by the wash of the water, fall asunder; they will tip over and, their whole surface being exposed to the warmer water, they will thaw away quickly. The formation of this peculiar structure of the ice is somewhat shrouded in mystery; but it seems to be due to a certain succession of temperature variations with the subsequent expansions and contractions of the ice. This does not explain, perhaps, why sometimes penknife ice is formed where only a short distance away the ice is compact.

When water freezes it expands with great force, and exerts a pressure which Trautwine estimates at not less than 30,000 pounds per square inch. The ice sheet, therefore, when formed on a lake, crowds its edge against the shore. With a fall of temperature the ice must contract; but being held at its edges by the friction on the sides, it cracks and opens into vertical fissures, or is, through its whole body, subjected to interior horizontal stresses. Therefore, the natural cleavage of the ice is always in vertical planes. Water enters these fissures for at least ten-elevenths of their depth, and often, lifted by capillarity to the upper surface of the ice, in freezing it fills them with compact ice.

When the temperature again rises, the whole ice body expands and, the old fissures being filled, a compression takes place which may produce new fractures. At the same time a thrust or shove is exerted toward shore, by which the ice is forced up the side slopes, carrying with it bowlders and loose material. A subsequent fall of temperature gives rise to new cracks, the water in them freezes and warmer weather again produces a shoreward thrust. Thus, the "shore wall" of the geologists is formed and the ice may be piled up to great heights. Having been exposed repeatedly to such expansions and contractions, the ice is strained in a similar way to that of the well known glass toys known as Prince Rupert drops. By a sudden shaking or percussion, it (the ice) may, like the glass drops, fall to pieces, forming a lot of needles very much like the prismatic vertical bodies into which granite, basalt or other plutonic rocks may cleave, this prismatic structure, perpendicular to the cooling surface, being common to other materials slowly solidified from a state of fusion.

The rate of expansion and contraction per degree F. for ice was found by Dumble to be 0.00000765 (0.0000033

\* Abstracts from a paper in the Journal of the Franklin Institute.

\* Nature, 1873.

at the freezing point), and, later on, by Andrews, for temperatures  $33^{\circ}$ ,  $16^{\circ}$ ,  $0^{\circ}$ ,  $-21^{\circ}$ ,  $-31^{\circ}$ ,  $-38^{\circ}$ , respectively: 0.0004088, 0.0002804, 0.0002048 and 0.0001974. This is more than for nearly any other solid.

It is evident that the interior strains produced by the temperature variations must influence the strength of the ice. Hence, the physical constants of crushing and tensile strength, elasticity, etc., must vary greatly with the present and former temperatures, even though we limit ourselves to consider only hard, solid and compact ice, neither cracked nor "rotten." Likewise do they vary with the purity of the water, its content of salts, etc. Trautwine gives the crushing strength of firm ice as 167-350 pounds per square inch. Colonel Ludlow, in his experiments in 1881, on 6-12 inch cubes, found 202-889 pounds for pure hard ice, and 222-830 pounds for inferior grades, and on the Delaware River 700 pounds for clear ice and 400 pounds or less for the ice near the mouth, where it is more or less disintegrated by the action of salt water, etc. Experiments of Gzowski gave 208 pounds; those of others, 310-330 pounds. The tensile strength was found by German experiments\* to be 142-233 pounds per square inch. The shearing strength has been given† as 75-119 pounds per square inch.

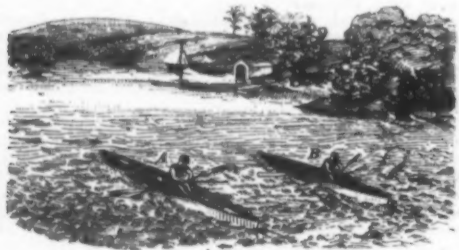
The coefficient of elasticity has been determined in different ways. By cutting out of the ice, floating on the water, along its three sides, a long and narrow rectangular strip, and loading the extremity of this tongue with weights, Bevan found a modulus  $77 \times 10^9$  pounds per square inch; but here the resistance of the water or the buoyancy influences the result. Trowbridge and Rue‡ removed the ice from the water and determined its elasticity by comparing the transverse vibrations of ice bars (13-13.7 inches long, 0.6-0.7 inch diameter) with those of a tuning fork, by measuring the transverse deflections of ice beams (3-7 feet long, 1.8-9 inches broad, and 1.8-4.3 inches thick), and by measuring the velocity of sound in ice. They found the latter to be 9,514 feet per second. The modulus of elasticity, as found by these experiments, was, respectively,  $87 \times 10^9$ ,  $102 \times 10^9$ ,  $119 \times 10^9$ , by longitudinal vibrations  $132 \times 10^9$  and, by the rise of the deflected beam after removal of the load,  $82 \times 10^9$ ; or, as an average of all,  $M = 119 \times 10^9$  pounds per square inch ( $84 \times 10^9$  grammes per square centimeter).

To determine now by means of these physical constants what weight an ice sheet of a certain thickness can safely carry, we must consider separately the different cases which may occur. The ice may support a single weight in one point or be uniformly loaded all over its surface. It may rest on the water, or this support may have been withdrawn by a lowering of the water level, such as usually takes place when the springs are frozen and the water evaporates, is absorbed by the soil, or runs off. It should also be borne in mind that the ice, according to Faraday, consists of distinct layers of different fusibility, perhaps alternately with and without a content of salts, perhaps only due to its above mentioned intermittent growth. This naturally tends to weaken the ice, as also do air holes formed by the confined air bursting it.

The army rules are that 2 inch ice will sustain a man or properly spaced infantry; 4 inch ice will carry a man on horseback, or cavalry, or light guns; 6 inch ice, heavy field guns, such as 80 pounders; 8 inch ice, a battery of artillery with carriages and horses, but not over 1,000 pounds per square foot on sledges; and 10 inch ice sustains an army or an innumerable multitude. On 15 inch ice, railroad tracks are often laid and operated for months, and 2 feet thick ice withstood the impact of a loaded passenger car, after a 60 feet fall (or, perhaps, 1,500 foot tons), but broke under that of the locomotive and tender (or, perhaps, 3,000 foot tons).

#### THE LOSS OF ENERGY DUE TO INTERMITTENT ACTION.

WHEN resistance has to be overcome by intermittent efforts, the loss of effective energy is considerable, and to explain fully what we mean, the cut is introduced. A and B are two rowers who apply their energy intermittently with their oars; now the resistance that a boat meets with in progressing through water varies as the cubes of the velocities, and therefore the velocities vary as the cube roots of the powers, and it is now our business to show that a force continually applied, propels a boat at a greater mean velocity than the same force would do applied intermittently, for the following reasons that will be given in proportionate instead of actual values. Suppose then a rower applies for the propulsion of his boat a power of 125 units of work every alternate second of time. We see that during one second 125 units are applied, while during the next second the momentum of the boat and its load is con-



sumed in its own propulsion; it therefore follows that the mean velocity of the boat will be  $\sqrt[3]{125 \div 2} = 2.5$ .

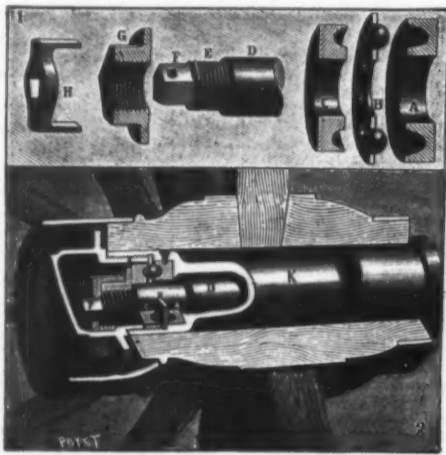
But if  $\frac{125}{2} = 62.5$  units of work are applied continuously

instead of 125 intermittently, the mean velocity will be  $\sqrt[3]{62.5} = 4$  nearly. Or while a continuous power will propel the boat 4 miles, the same power applied intermittently will only propel it 2.5 miles. Now what is true of the boat is also true of the fan, for the power producing mine ventilation varies as the cubes of the

velocities, and as a jerking pulse, or wave motion, takes place in the air stream flowing through a fan in which the orifice of discharge is too large, and therefore the difference between T and M is too small, we have a cause of intermittent action as in the boat. All mine currents move pulsatively, and very markedly so, when the resistance is considerable; and when therefore the difference of potential already referred to is small, the jerky pulsations of the mine current enter the fan and react on the engine, and the result is such a fan as an open one, with a very large area of discharge, gives out a small percentage of efficiency. The loss of energy in the fan often arises from another cause, as where the blades are too short, and therefore the fan has to be run at a high velocity to obtain the required difference of potential, and the result is the velocity of the fan is constantly varying as the engine passes through full crank and the dead points.—Colliery Engineer.

#### BALL BEARINGS AND RUBBER TIRES FOR CARRIAGES.

Up to recent years, horsemen have considered the bicycle so unworthy of their study that they have long lost the benefit of the wise improvements therein in



FIGS. 1 AND 2.—BALL BEARINGS FOR CARRIAGES.

carriage building, of which, nevertheless, it is the initiator. Now that cycling has become an elegant sport, it is beginning to be admitted that it is a useful and ingenious one, and one worthy of attention, and certain peculiarities of the construction of bicycles are now tried upon the heaviest apparatus of locomotion. At the last cycle exhibition there were to be seen, at the entrance to the galleries of auto-mobile locomotion, carriage wheels suspended freely upon their axles, and to which the least stroke of the finger seemed to impart an indefinite rotary motion. These were the first trials of axles with ball bearings for carriages made by the Belvalette establishment: an evident inspiration of cycling. Rolling upon balls, in fact, has had the privilege of much astonishing the common run of mortals. It is generally thought that this arrangement is an invention due to the bicycle, while as long ago as 1857 there existed a patent relating to a system of ball bearings applicable to bells, millstones, thrashing machines, etc. The first to apply balls to cycles was a Mr. Suriray in 1869. However this may be, it is certain that Mr. Belvalette, himself a veteran in cycling, improved the rolling of his carriages by a clever copy of the rolling of a bicycle. We say clever copy, because it was a question of making a strong axle whose balls could not escape from the awkward hands of a groom, and the regulating of which should be both easy and mathematical.

After numerous tentatives, Mr. Belvalette has fixed upon the following arrangement: The axis, D, that Fig. 1 shows, and that in Fig. 2 is represented in the hub, K, supports a piece, C, whose channel has a triangular profile and which forms the counterpart of a

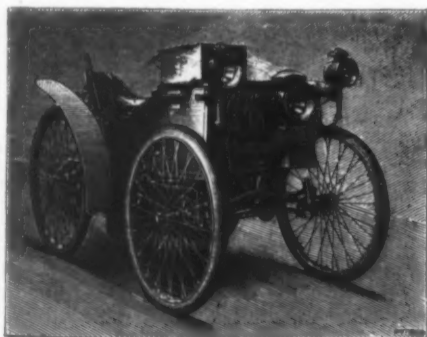


FIG. 3.—AUTOMOBILE CARRIAGE WITH RUBBER TIRES.

piece, A, of the same profile mounted upon the hub. Between the two a disk, B, provided with apertures, holds the balls. These apertures are of a slightly smaller diameter than that of the balls. The extremity of the axle is provided with a thread, E, and a pentagonal part, F. Upon the thread is screwed a nut, G, that is held by a bronze clamp, H, which, through its combination with the end of the journal and the regulating nut, permits of varying the tightening of the nut thirty times in a single turn, that is to say, of regulating it to  $\frac{1}{30}$  of a millimeter. A leather washer is interposed between the axle washer and the box,

when the latter is upon the axle, for intercepting the passage of oil and dust.

As may be seen, the arrangement is simple and substantial. Conscientious experiments with a couple thus mounted with ball bearings, made with the aid of the dynamometric carriage of the Compagnie Generale des Voitures at Paris, have demonstrated that the improvement in rolling is about 30 per cent. upon a good level road and about 20 per cent. upon a flat road covered with snow. Admitting even that such figures were not confirmed in their entirety in practice, it is none the less certain that rolling upon balls saves a number of miles on the part of the horse. Were it therefore only from the view point of rendering, the application would be most valuable.

A second and very important infiltration of cycling into carriage building is certainly the adoption of the rubber tire. It was two or three years ago that the first experiments were made with it on the coupé of the manager of a large English bicycle manufactory; but the difficulty of putting on and taking off the type of tire selected gave a check to the idea for some time. The idea was taken up again in France. Upon the occasion of the race of auto-mobile carriages in June, the curious were not a little surprised to see among the competitors a quadricycle of the respectable weight of 2,400 pounds provided with four large rubber tires (Fig. 3). It was an innovation and a demonstration made by Mr. Michelin, the Pater Eneas of rubber tires in France.

Of the total weight, the front wheels carried about 200 pounds each and the hind ones about 1,000. How would a rubber tire withstand such a weight, and how would it behave on curves, upon which there is always

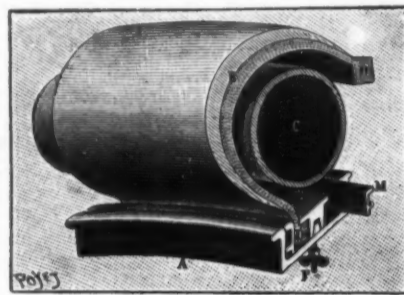


FIG. 4. MICHELIN RUBBER TIRE FOR CARRIAGES.

a great danger of the rubber being wrenched from the tire? Here was a new and difficult problem to be solved. Mr. Michelin devised the tire represented in section in Fig. 4. The felly, A, which is of first-class steel, has the form of a flattened U. In its center, large bolts, E, having the form of a  $\pi$ , and screwed into the bottom of the felly by a series of thumbnuts, hold between them and the edge of the felly the parts, D, of the tire, B, covering the air chamber, C. In order to increase the adhesion and prevent stripping on curves, it is well to interpose between the edge of the tire and that of the felly metallic pieces, M, which fill up the groove and are held firmly in place by the pressure of the air. Such a tire can be inflated, without any danger of explosion, to 8 atmospheres—a pressure that has never been practically reached, and that in any event the character of the valve permits of obtaining with a pump of small caliber. As for dangers of perforations by nails, they, so to speak, do not exist, the thickness and the number of the canvases necessitated by the pressure of the air and the stress of traction rendering punctures almost impossible.

The application of the rubber tire to carriages drawn by horses or to auto-mobile vehicles is evidently a great progress, in that it suppresses, at least partially, the inequalities of the road and the shocks that it produces—such shocks being very prejudicial to the carriage as well as to its motor. It will cause builders of auto-mobile carriages to get out of the rut in which they are moving—the construction so much the more resistant (that is to say, so much the heavier) in proportion as it is desired to run faster. The formula  $mv^2$  irrefutably bars the road to badly suspended auto-mobile carriages.

The objection is the fragility of the pneumatic tire; but this is not of much account, since, upon the whole, the rubber tires of carriages are difficult to perforate and the repair of them is in all cases much easier than that of the metallic assemblages that they protect from jarring. The adoption of ball bearings and rubber tires will gradually lead builders to seek a light and consequently so much the faster carriage. The huge three and four thousand pound vehicles have thus taken a lesson from the little twenty-five pound bicycle.—La Nature.

#### ATTEMPT TO LIQUEFY HELIUM.

PROFESSOR WILLIAM RAMSAY in a note to Nature says: "I have received a letter from Professor Olszewski, of Krakau, in which he informs me that having exposed a sample of helium which I sent him to the same treatment as was successful in liquefying hydrogen—namely, compressing with a pressure of 140 atmospheres, cooling to the temperature of air boiling at low pressure, and then expanding suddenly—he has been unable to detect any sign of liquefaction.

"The density of helium being, roughly speaking, twice that of hydrogen, it is very striking that its liquefying point should lie below that of hydrogen. It may be remembered that argon, which has a higher density than oxygen, liquefies at a lower temperature than oxygen; and it was pointed out by Professor Olszewski that this behavior was not improbably connected with its apparently simple molecular constitution. The similar fact now recorded for helium may therefore be regarded as evidence of its simple molecular constitution. I use the word 'its' instead of 'their,' although further research may corroborate Professor Runge's contention that what is termed

\* Engineering News, 14, 1886.

† Nature 1, 1870.

‡ Am. Journ. of Science and Arts, 129, 1886.

helium may in reality be a mixture of two, if not more than two elements. If this contention is true, both, or all, must have extraordinarily low boiling points."

#### THE DENSIMETER APPLIED TO THE ANALYSIS OF LIME IN THE SOIL.

VOLUMES might be written upon the subject of the influence of limestone upon vegetation and upon the conditions of its assimilability, which, moreover, have been rather guessed at than determined. But the first question that presents itself to the agriculturist is the following: How much lime does dry earth contain per one hundred parts in weight? In order to obtain an answer to this first interrogatory, which is absolutely relative, it is necessary to have recourse to chemical analysis and laboratory instruments, or to make use of the excellent apparatus invented by Mr. Adrian Bernard.

But if the agriculturist cares neither for rigorous precision nor for great rapidity of execution, he may dispense with the purchase of costly instruments, inclusive of an analytical balance, and even do without the Bernard calcimeter. Provided that he has acquired some little experience in elementary chemical manipulations, he may operate at still less expense by following our directions. His material for quantitative analysis will be reduced to a musimeter or densimeter graduated from 1.100 to 1.200, such as is furnished by all good opticians, to a matrass gaged 200 c. c. (or 240 on having it made upon order), to a test glass with areometer, and, finally, to a mercury or alcohol thermometer engraved upon the tube. A few small accessories are necessary, but a pharmacist or druggist can supply these, as well as the reagent indispensable, viz., hydrochloric acid or the "spirit of salt" of commerce.

If we pour a certain quantity of this yellowish liquid into the test glass, we shall find that upon plunging the densimeter into it the meniscus will find its level at the division 1.100. Such, in fact, is the density of the common acid. But if we gradually add pure water to our acid, in mixing well each time, the graduated tube will sink. If we proceed quite carefully, we shall succeed, by dint of trials, in causing the areometer to sink to the upper division mark, 1.200. When once such condition has been realized,

gaging in the market, it will be necessary for the experimenter to have one made upon order or to make it for himself.

The first bottle that comes to hand, provided it has a capacity of a liter and a half or one liter at a minimum, will perform the role of a reaction vessel. Into this latter, supposed clean and dry, we introduce the desired weight of earth, to which is afterward to be added the corresponding volume of acid at 1.100 in making use, if need be, of a glass rod and in moderating the flow of the reagent if too much foam disengages—a thing that often happens with very calcareous soils. After the tumultuous reaction has ceased the bottle is corked to prevent evaporation, and, after all gaseous disengagement has ceased, the liquor is filtered into the gaged vessel in order to incorporate with the transformed solution the traces of acid adherent to the sides. As soon as a sufficient volume of filtrate has been collected, we proceed to the areometric weighing.

In case there is a long series of analyses to be made, we would recommend to the experimenter the apparatus that we figure herewith, and that may be constructed without expense in localities perfectly destitute of resources. A glazier will easily drill the lateral orifice of the bottle, and this orifice may be closed by means of the rubber stopper of a Salleron alembic. The rubber coupling tube may be taken from a nursing bottle, and may be closed by a spring clothes pin whose jaws will have been rendered plane through the adjoinment of two opposite strips of wood.

The earth is introduced into the bottle without loss by means of a funnel of glazed cardboard or of a visiting card bent into the form of a gutter in making use of one of the two openings, the other being closed. The lower hollow stopper is inserted, if it has not been already, and the rubber tube is clamped. The acid is now carefully poured in through the neck, and, after the effervescence has ceased, the bottle is corked and gently shaken. It suffices at the end of a certain length of time to loosen the clip in order to draw off the relatively limpid stratum that floats upon the muddy deposit accumulated at the bottom of the bottle. We thus obtain a nearly clear portion that it is well, however, to allow to settle in a closed vessel until it becomes perfectly transparent. One should have calculated in advance the height of the lateral orifice so as to obtain by this very simple process the liquid

bon the carbonic acid of the air. But what about the source or sources of the nitrogen? In the year 1840 Liebig brought out his famous treatise on Organic Chemistry in its Application to Agriculture and Physiology, the publication of which, as Dr. Aitken justly remarks, forms the greatest epoch in the history of scientific agriculture. In this memorable work Liebig gives it as his definite opinion that the one source from which plants derive their nitrogen is the ammonia of the air (or its products of oxidation, nitrous and nitric acids). "He dismissed from his mind the idea that plants could take any of their nitrogenous matter from the free nitrogen of the air, because he knew that nitrogen was the most indifferent among the elements (argon and helium being then unknown), and naturally imagined that if plants could make use of free nitrogen they would not exhibit, as they did, such an avidity for nitrogen in the form of ammonia salts."

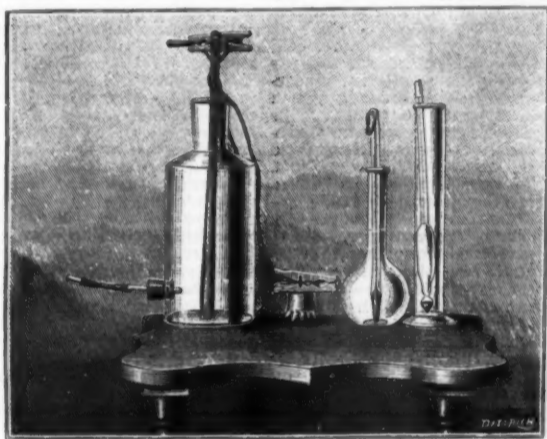
But this was a case in which, as we know, Liebig was mistaken. The first man to make a definite experimental investigation of the subject, such as was fitted to produce results of any value, was the well known French chemist, Boussingault (1802-1886), a contemporary of Liebig, and one of the most eminent among agricultural chemists. His experiments had been in progress for some years prior to the publication of Liebig's great work. He grew plants in an artificial soil containing no nitrogenous matter whatever, the whole being inclosed in a small chamber into which no air was allowed to pass that had not been previously deprived of every trace of the ammonia or other nitrogenous compound that it contained. Under those circumstances, if the plants were to absorb nitrogen, that nitrogen must be the free nitrogen of the atmosphere. These conditions of culture were, however, such that the plants hardly grew at all in the ordinary sense of the word, the whole produce weighing only two or three times as much as the original seeds. As a result Boussingault found in the ultimate crop—whether of oats, beans, cress or lupines—no more nitrogen than was originally present in the seeds when they were planted. Notwithstanding the unnatural conditions of growth, however, he was eventually so satisfied with the results of his experiments as to have no hesitation in concluding that plants could not absorb free nitrogen from the air, and this opinion, coming as it did from such a distinguished authority, was for long received as correct.

In the year 1840 the late M. Georges Ville, director of the Agricultural Experiment Station at Vincennes, near Paris, began a long and laborious research on the same subject, being of opinion that Boussingault's results were not to be relied upon, inasmuch as the conditions of growth were unnatural, the plants experimented upon having never really entered into an independent state of existence. "He, therefore, managed his plants in such a manner as to enable them to attain a good normal growth. They were kept under cover, but well ventilated. The soil afforded them was abundant and contained a certain definite amount of nitrate of soda, and the roots had plenty of room to increase, and they were also provided with good drainage and ventilation. The result was that his plants grew to be ten, twenty, fifty or one hundred times or more the weight of the seed, and in their substance they contained more nitrogen than was contained in the seed and the soil together."

Since no nitrogenous matter other than the known amount of nitrate of soda in the soil and the free nitrogen of the air had access, M. Ville came to the conclusion that plants, or at least certain plants, could and did assimilate free nitrogen.

Ville's deductions, however, were by no means accepted as correct, being in absolute contradiction to those of Boussingault. The discussion over the point became very warm, and ultimately the French Academy, of which Boussingault was a distinguished member, accepted Ville's offer to appoint a commission to examine his apparatus and superintend his experiments. This commission reported that M. Ville's conclusions were justified by the results he had obtained, but the members composing it were not satisfied that the plants had not been supplied with ammonia as an impurity in the distilled water used for watering them. M. Ville ended his experiments in 1857, and in that year Messrs. Gilbert, Lawes and Pugh undertook a repetition of Boussingault's experiments at Rothamstead, being careful to conduct these in such a manner as to meet any possible objection that might be taken to any part of Boussingault's procedure. Their results entirely confirmed those of the famous French chemist. Notwithstanding all this, M. Ville still maintained the accuracy of his own results, and published in 1867 a new and extended edition of his researches in which he reviewed and criticised the work both of Boussingault and of the English experimenters already cited. He maintained that in these the plants suffered from want of ventilation, that they were usually sown at the wrong season of the year, that the quantity of soil used was inadequate and that—owing to this last circumstance—the mineral manurial matter was too concentrated, and so interfered with the development of the plants. He further pointed out the futility of comparing plants of immature growth with fully developed ones, and also gave some experimental proof for the important statement that "plants do not begin to assimilate the free nitrogen of the air until they have attained a stage of development in which they have acquired at least ten times the weight of the seed they grew from. He regarded this as the minimum of progress; but in some of the experiments recorded it was evident that a later stage of development had to be reached before the power of assimilating the free nitrogen of the air was acquired."

According to Ville, therefore, a certain amount of nitrogenous food must be supplied to plants grown in an artificial soil, in order to bring them to that stage of growth at which they are able to take up nitrogen directly from the air, the amount required depending upon various circumstances. He showed that a certain minimum of nitrogen (i. e., nitrogenous manure) was necessary, and also that there was a certain maximum which must not be overstepped. If this maximum was exceeded, then the plant never drew on the atmospheric nitrogen at all, but preferred to feed on the more easily assimilable nitrate of soda or other nitrogenous matter in the soil. Dr. Aitken adverts to his having "referred at length to Ville's experiments, conducted upward of forty years ago, and republished



APPARATUS FOR ESTIMATING THE PROPORTION OF CARBONATE OF LIME IN ARABLE SOIL.

we shall have prepared the "type liquor," a proper supply of which may be preserved in well stoppered bottles. Let us add that the type liquor should be obtained at 15° C. by diluting the reagent with tepid or cool water, according to the season, and that a cooling or heating of 5° amplitude forces or lowers the density by two units of the order of thousandths. Let us treat a volume determined and measured at 15° (200 c. c., if you please) of our type liquor with very fine powder of pure white marble. The latter will dissolve with effervescence, and, after the end of the attack, the cooled liquor will show a perceptible increase of density, because, while losing acid, it has become heavy through the incorporation of chloride of calcium. The experiment proves that equal weights of marble cause the same number of divisions of the graduated tube to emerge, and that, in the example selected, 41.6 gr. of marble or pure limestone increase the primitive density by 100 units and raise it to 1.200.

Such is the principle of our method. The rest may be divined. It suffices to take, instead of 41.6 gr. of marble, an equal weight of dry earth and to treat it with 200 c. c. of acid at 1.100. The silica and clay will not take part in the reaction. The limestone alone will dissolve and increase the density of the liquid according to its abundance. If the areometer is then immersed up to the 1.200 mark, for example, the earth contains 20 per cent. of limestone, or weighs 20 calcimetric degrees. It will be necessary, however, to assure ourselves at this moment that the temperature of the liquid does not differ from 15°; if it does, we must correct at the rate of 2 calcimetric degrees per 5° C. of deviation. This reasoning admits that no other substance but lime has dissolved in the reagent. Such a supposition is absolutely erroneous only in exceptional cases, with soils rich in bauxite or phosphates, for example. Usually, the error committed does not exceed, at the furthest, 1 calcimetric unit. The landowner will care but little to know that his soil contains but 19 or 19.5 per cent. of lime, instead of 20 per cent.

Further, we may do without a balance of precision and be content with an ordinary apparatus sensitive to a decigramme. There is nothing, even, to prevent us from substituting for the complex quantity of 41.6 gr. a weight of earth equal to 50 gr. exactly. Only it is well to increase the quantity of type liquor proportionately, the requisite volume of which becomes 240 instead of 200 c. c. As we do not find matrasses of such

volume proper for the areometric test. The apparatus should be immediately taken apart and rinsed out, and will then be ready for another experiment.

Commercial hydrochloric acid is a common product of so low a price that it is of no interest for druggists to adulterate it knowingly; but, through carelessness, it may be contaminated with sulphuric acid. If such be the case, the fact may be easily ascertained by dissolving marble in powder in the suspected acid. As the sulphuric acid brings about the formation of insoluble sulphate of lime, a turbidity will manifest itself that will not disappear upon the addition of water. If, on the contrary, the solution sensibly preserves its limpidity, the acid is good, and it only remains for the agriculturist to form his type liquor through successive tentatives that will greatly exercise his patience, for, after every new addition of a small supplement of water or acid, it will be necessary for him to cork the vessel and invert it several times in order to render the mixture homogeneous.—La Nature.

#### THE NITROGEN OF THE AIR AS A PLANT FOOD.

By GEORGE MCGOWAN, Ph.D.

IN the whole range of agricultural science there is no problem whose solution has presented greater charms and, it may be added, greater difficulties than the following one: Are plants capable of feeding directly upon the nitrogen of the air or are they not? Or, to put the query in other words, Can plants assimilate free nitrogen, or must their nitrogen be presented to them as food entirely in the form of a nitrogenous compound such as ammonia or nitric acid? The recently published volume for the current year of the Transactions of the Highland and Agricultural Society contains a most interesting paper on this subject by Dr. A. P. Aitken, the well known authority on agricultural chemistry, and we think that we cannot do better than bring a résumé of this before the readers of Knowledge, since it covers within short compass the main points of the whole subject.

Apart from the purely mineral constituents (phosphates, potash, etc.) which plants extract from the soil, they are built up from the four elements, carbon, hydrogen, oxygen and nitrogen, the source of the hydrogen and oxygen being water and the source of the car-

by the author about thirty years ago, because, although they were pretty generally discredited at the time, and their results were at variance with those of other more distinguished experimenters, they will be found, as I shall show hereafter, to be a remarkable anticipation of the most recent discoveries regarding the relation of plants to atmospheric nitrogen."

Notwithstanding the fact that Ville's experiments failed to convince the majority of chemists, a suspicion remained in the minds of some that the nitrogen of the air must in some way or other become available for plants, either directly or indirectly. How else was the "balance of nitrogen" in the atmosphere maintained, seeing that there was actual experimental proof that, by the decomposition and combustion of both vegetable and animal matter, a certain proportion of the nitrogenous matter that they contained was constantly being broken up, with the liberation of free nitrogen? And the same thing occurred when nitrates were mixed with soils rich in humus. On the other hand, it was perfectly well known that large quantities of nitrates were lost from the soil in drainage waters. Everything, therefore, pointed to some compensating process or processes by which the free nitrogen of the air was taken up by plants, so as to redress the waste of nitrogenous compounds continuously going on throughout the world. Various natural chemical processes have been suggested at different times as affording the means of this redress—for example, the formation of nitrite and nitrate of ammonium in the air through the agency of the electric discharge during thunderstorms. But it became obvious, after due consideration, that these could only compensate a small part of the loss of the combined nitrogen, and that it must evidently be to some action of plant life that we must turn for an explanation of the riddle. This brings us to a very important paragraph in Dr. Aitken's paper: "It had been known for many centuries that the growing of leguminous crops was a means of enriching the land in such a manner that after clover, vetches, or the like, an increased yield of wheat or other cereal crop could be obtained; and, since chemistry has come to the aid of agriculture, it has been discovered that the reason why leguminous crops favor the growth of succeeding cereals is that they leave the soil richer in nitrogenous matter than it was before, and this despite the fact that the leguminous crops themselves are distinguished among all other crops by the large amount of nitrogenous matter they contain."

Mention is then made of the important experiment, extending over many years, carried out by Herr Schultz on his property of Lupitz, in Altmark, Germany, which did more than anything else to bring home the above truth to agriculturists; it should just be stated, in passing, that this experiment was originally undertaken with a view of improving poor, light soil, and not for any scientific purpose. Herr Schultz came into possession of his property in the year 1855, at which time the land was so poor that it could not grow oats, and, in order to obtain a fair crop of rye, it was necessary to adopt a system of green manuring with lupines. By following Liebig's teaching in applying superphosphate, kainite and marl, all of which are non-nitrogenous manures, he found that the lupines responded wonderfully. And the above-mentioned system of green manuring (i. e., of growing lupines or some other leguminous crop one year, and either plowing these in, preparatory to taking a crop of rye, or cutting the lupines for fodder) had for its result that the soil became steadily richer in nitrogenous compounds year by year. It is now forty years since this system was begun, and it is still being continued; and although large crops rich in nitrogenous matter are taken off the ground annually, yet the soil is now three times richer in nitrogen than when Herr Schultz began to work it. "These experiments of Schultz tell us nothing about the source of the nitrogen except that it came from the air, but whether it (this source) was the ammonia of the air or ordinary atmospheric nitrogen could only be a matter of conjecture. Considering, however, the smallness of the store of atmospheric ammonia, and that leguminous plants under manurial treatment show no liking for ammonia salts of any kind, and are apt to be the worse rather than the better for them, even when applied in quantity ten times less than the equivalent of that contained in the crop, it seemed in the highest degree probable that the source of the great gain of nitrogenous matter must be sought for in the free nitrogen of the air."

"The remarkable effects produced by growing lupines and other leguminous plants at Lupitz required to be studied from some other point of view than the merely chemical one"—i. e., from the biological.

The next step toward the solution of the question was the discovery in the year 1877 of the now well-known process of "nitrification" in soils, by two French chemists, M. M. Schloesing and Müntz. Of this discovery—a discovery which, as Dr. Aitken remarks, has worked nothing short of a revolution in our method of viewing the relations of the soil to plant life—nothing more need be said here than that it has been abundantly proved by numerous experimenters that complex nitrogenous matters existing in ordinary soils undergo oxidation by the oxygen of the air, first into nitrites and then into nitrates, by the agency of perfectly definite microbes; and some of these latter have been isolated independently, after long and patient endeavors, by Messrs. Winogradsky, P. Frankland, and Warington. The nitrates thus produced by the microbes are then directly available as plant food.

Messrs. Hellriegel and Wilfarth then made a special study of the small tubercles which had long ago been observed in the roots of the lupine and plants of the same order. A microscopic examination of the tubercles showed that they contained bacteria, and a mass of bodies somewhat resembling bacteria, and hence called bacteroids, while careful experiments proved that these tubercles only made their appearance on the roots of lupines, etc., when the latter were grown in ordinary soil, while plants grown in sterilized soil were free from them. It thus followed that the bacteria had their origin in the soil. The next point to be determined experimentally was, what is the specific effect of these tubercles, or rather of the bacteroids which they contain, upon the growth of the plant? The investigations entered into with the view of elucidating this led to the following results, the value of

which cannot be overestimated, viz., "that when cereals and leguminous plants were grown in a sandy soil to which the requisite mineral manures were added, and the nitrogenous matter given in the form of nitrate, the cereals made growth and attained vigor in direct proportion to the amount of nitrate given to them, when the amount provided was small; so that a double dose of nitrate caused the growth of a twofold amount of organic matter, a treble dose gave a threefold increase, and so on until the amount of nitrate had been added which enabled the plants to grow to their normal size, when, of course, the further addition of nitrogen had less and less effect upon the amount of organic matter produced. The cereals were able to assimilate the nitrate directly, and their growth in a soil otherwise fertile depended precisely upon the amount of nitrate present. With the leguminous plants no such correspondence was observed. Their growth was quite capricious, and, indeed, sometimes the soil containing the least amount of nitrate produced the largest and healthiest plants. It seemed from many experiments that leguminous plants—such as peas, clover, and lupines—were very little dependent on the nitric acid (i. e., the nitrate) of the soil for their nitrogenous nourishment."

It followed from this that the source of nitrogen for leguminous plants, at all events, must be atmospheric nitrogen, either combined or free; and—not to weary the reader with too many details—it was conclusively established by the experimenters just named that the free nitrogen of the air constituted this source. It was further found that the ability of the above order of plants to assimilate free nitrogen was associated in some way with the tubercles in their roots. "Lupines which were grown in sterilized soil, but provided with all the elements of fertility, might grow well enough, but the crop produced contained no more nitrogen than had been provided in the soil and in the seed, and their roots contained no tubercles. On the other hand, when grown in a soil containing very little nitrogen, but in which the micro-organisms associated with the growth of tubercles were present, it was noticed that the plants grew to a certain stature and then began to droop. Cereals grown under similar conditions presented a similar appearance, and eventually died down; but in the case of the lupines, after passing through the drooping stage and losing some of their leaves, they revived, shot out new leaves, and grew at length to full stature. When the crop was analyzed, and also the soil in which it was grown, it was found that there was a notable increase of nitrogen in both." "This is precisely what Georges Ville found in his experiments thirty years before, and which he described to an incredulous world, and the conclusion he arrived at was the same, viz., that leguminous plants are able to utilize the free nitrogen of the air in building up their tissues." (Of course Ville had not at that time any idea of the agency of micro-organisms here.) The accuracy of Hellriegel and Wilfarth's results has since been thoroughly verified, the assimilation of nitrogen by leguminous plants and the growth of the tubercles having been made the subjects of prolonged study and observation. Much, however, still remains to be found out in regard to this, for, as Dr. Aitken says, while the fact that leguminous plants do assimilate free nitrogen seems to be abundantly proved, the place where the assimilation occurs and the conditions under which it occurs are still matters of conjecture.

Berthelot has shown further that—altogether apart from the growth of leguminous plants—some soils are capable of absorbing the free nitrogen of the air, this being due to the presence of small unicellular algae. Later researches of Kossowitch, on the other hand, appear to show that algae have only an indirect, but none the less important, influence upon the process. Prof. Frank, of Berlin, after long study of the subject, has been led to the conclusion that the tubercles on the roots of leguminous plants are not the cause of their ability to absorb free nitrogen, but they are rather the result of that process. He is also of opinion that the seat of the assimilation of free nitrogen is to be found in the chlorophyll cells, where it was long ago proved that the decomposition of carbonic acid by plants and the fixation of its carbon takes place.

"He (Prof. Frank) makes no difference between leguminous plants and others as regards their ability to assimilate free nitrogen in their chlorophyll cells, while he acknowledges that that order of plants possesses the power in a very remarkable degree. He is, therefore, of opinion that while fallow land, poor in organic matter, may become richer in nitrogen through the growth and nitrogen assimilation of minute cryptogams therein, that enrichment is greatly augmented when plants of a higher order are grown upon the land."

From what has been said it will be seen that the whole question of the assimilation of free nitrogen is in a most interesting stage. But the actual and hard-won experimental proof of the fact that the free nitrogen of the air, as such, can be taken up and is taken up by certain kinds of plants, assuredly marks an epoch in the history of agricultural science. Readers who desire to enter into the subject more fully should refer to Dr. Aitken's able paper, for which the thanks of all who are interested in scientific agriculture, but who are precluded through want of time or otherwise from entering minutely into such points themselves, are due.—Knowledge.

#### HOW TO MAKE THE BRAINS GROW.

At a recent meeting of the Educational Club, Philadelphia, Dr. Elmer Gates delivered a lecture before a large and interested audience entitled "Psychology and the Mind Art." The *Ledger* says:

Dr. Gates began by saying that about twenty years ago he observed that on some days his ideas came free and easy; that it was easy to contrive experiments and inventive devices; that it was easy to understand and learn a difficult subject, and that he was full of exhilaration and good humor. He noticed that on other days, and often for quite a period of days, he was unable to achieve a single new idea, or to contrive the simplest inventions. Seeing that the advent of new ideas did not always follow the acquisition of new facts, and that at other times new facts were soon the beginning of new ideas and insights, he began a study of the causes which promote or hinder original

thinking. Pupils having nearly the same mental capacity may witness the same phenomena or make the same experiments, and one will often strike out valuable new ideas and the other will not, and it is not always the seemingly brightest pupil that attains to the new ideas. Sometimes the acquisition of new data is immediately followed by original ideation, and at other times not for years, when suddenly the new insight dawns in the mind without having acquired new data upon that particular subject.

Dr. Gates then described how, by means of careful observations of his own bodily temperatures and their rhythmical variations of perspiration changes, of his respiratory rhythms, his food, exercises, salivary conditions, hunger, thirsts, appetites, fatigues, pains, and other organic conditions, he found many interesting facts concerning the operations of the mind. He found that certain organic conditions and habits interfered with brain operations, and that certain others promoted them, and that certain environmental conditions hindered organic thinking and certain others augmented it. His discoveries he collected, and reduced into a rational system the mental habits and processes of the thinker and investigator. He carefully studied the physiological periodicities and rhythms of the thinking functionings, and found that there are appropriate times for one kind of mental work when other kinds cannot be performed with equal efficiency. He also discovered that the human organism transforms and utilizes energy at different rates and with different degrees of efficiency when engaged in different kinds of mentation, and that thinkers and investigators usually waste most of their energy in wrong mental habits and by antagonizing cosmical conditions. Dr. Gates said that there are favorable conditions of temperature, moisture, air, electrostatic potential, altitude, diet, exercise, etc., which promote mentation functionings, and other conditions which must be prevented, that hinder such mentations. It is possible for one to learn the art of recognizing and controlling these conditions.

Dr. Gates then proceeded to give examples of what he meant by perception, conception, imagination, ideation, thinking and so on. By exercising one of these faculties upon each and all the data of one group of phenomena for one or more hours each day, that kind of functioning becomes strengthened, and those parts of the brain where the functioning is most localized will have more blood, will produce more metabolisms, or chemical changes, and will grow. When one applies some other faculty to these same data other parts will grow, and so on until all of the faculties of the mind will have been strengthened and specialized, and the pupil will have become familiar in the use of these faculties. Several hours daily the pupil applies in turn each one of his distinct mental functions to each one of the data of the science, art or business which he is studying, and thus not only strengthens each of those faculties, but, while doing so, he discovers many incongruities, new relations and so forth between the data. But he is doing more than acquiring such skill in the use of his mental functionings as has hitherto been unknown—he is strengthening and growing these very parts of the brain which are especially needed in the study of that particular subject, and bringing into consciousness those unconscious mentations which constitute the basis of all conscious thought.

Dr. Gates then spoke of the art of origination mentation which his discoveries and investigations naturally led to—the art in which the subconscious functionings of the brain, composing, as they do, 90 per cent. of our mental life, are systematically regulated. He also referred to conscious origination mentation in which each and all of the mental faculties and functions are trained to their most efficient normal functionings in scientific research, invention, discovery, study, speech, working, and all kinds of practical activity.

The lecturer proceeded to develop more in detail the method of toxic brain building, as well as the art of curing immoralities, concluding his lecture by stating that the art of original thinking is simply the art of scientifically accumulating the data to think with, the art of systematically applying all of the mental faculties to the process of thinking, the art of promoting the functioning of the entire organism so as to favor mental progress, and the art of regulating the environmental conditions to the same end.

#### A RATIONAL CURE FOR SNAKE BITE.

WHEN it was established beyond dispute or cavil that the serum obtained from animals, immunized against bacterial infections and intoxications, possesses in a marked degree antitoxic powers—as distinguished from antibiotic powers—and that such serum when mixed in a test tube with the bacterial poison in question will, so to speak, neutralize the toxic effects of such poison, however deadly, it was merely a question of time, opportunity and patience that attempts would be made to enter the principle of serum immunization to other, i. e., non-bacterial poisons. Ehrlich was the first to show us the way. He gradually accustomed animals to withstand comparatively large doses of abrine, ricine and robine, three vegetable toxins, all belonging to the group of proteins, reacting as albumoses or globulines.

In that manner he produced in the animals a relative immunity, or perhaps, more correctly, a tolerance. He found that though subcutaneous inoculations lead to better results, that this immunity can be brought about also by feeding. In whatever way the animal is prepared its serum eventually acquires specific antitoxic immunizing and curative properties. It was thus demonstrated that the wonderful discovery of Behring and Kitasato—for which Behring, however, claims the sole credit—has a scope much wider than at first was dreamt of.

Behring himself, to begin with, explained the action of the serum as antibiotic or germicidal; but it soon became evident that though when injected into the animal body it causes the destruction and death of the infective pathogenic organisms, nevertheless its chief action is "vitality" anti-toxic. For working with the tetanus toxine alone, separated from the bacilli which produced it, its deadly effects can be readily neutralized by a few cubic centimeters of a powerful serum. And if we remember that 0.23 milligramme of

tetanus toxin would represent the fatal dose for a human being weighing 70 kilogrammes, then we can get an idea as to what extraordinary changes must have been produced in the serum, or rather in the blood and tissues of the immunized animal, to enable its serum instantaneously to remove the lethal effect of the toxin. The only poison comparable to tetanus toxin in virulence and rapidity of action is cobra poison, and it also resembles chemically the bacterial toxins reacting as an albumose, though for the sake of accuracy it must be mentioned that the poison of tetanus has been clearly shown by Brieger, Cohn and Sidney Martin not to be an albuminous body, and that possibly most of the bacterial toxins may turn out not to be albuminous substances. Still, so far as our present knowledge reaches, cobra poison and other snake venoms are chemically closely allied and analogous to the "toxalbumins" of bacteria.

It had also been demonstrated by several observers\* that by means of oft-repeated injections of small sublethal doses of snake poison (rattlesnake, cobra or viper venom) the resistance of an animal against the poison may gradually be increased considerably; it may be rendered "gifttest," to borrow a German expression. In fact, all the methods used for inducing a tolerance against tetanus poison can be shown to work in the case of cobra poison (this is the poison generally employed). Thus Calmette, whose work in this line follows directly that of Sewall's and of the writer of this article, has shown that a so-called immunity can also be produced by gradually increasing injections of poison attenuated by heat, iodine, trichloride of iodine, hypochloride of calcium, etc.; in fact, the analogy is complete. From this stage, at which others had already arrived, Calmette went ahead with Phisalix and Bertrand. Having previously attempted both to prevent and to cure the effects of inoculation with cobra poison by means of chloride of gold—wherein, however, as shown by the writer,† he failed—he directed his attention at once to the serum of immunized animals, and in February, 1894, he showed before the Société de Biologie that on mixing cobra or viper venom with small quantities of serum obtained from an immunized rabbit the deadly effect of the venom disappears, a fact at once confirmed by independent observations of Phisalix and Bertrand.

In May, 1894, and in April, 1895, Calmette published two concise papers in Pasteur's *Annales*, containing a full account of his results. These, briefly summarized, are as follows:

(1) The serum of an animal immunized against snake poison (he used poisons of the following snakes: *Naja tripudians* and *haje*, *Orotalus durissus*, *Bothrops lanceolatus*, *Cerastes*, *Pseudechis porphyriaeus*, *Hoplocephalus curtus* and *variegatus*, *Acanthopis antarctica*, *Trimeresurus viridis*) possesses properties similar to those which the serum of animals immunized against tetanus and diphtheria possesses.

(2) The serum of a rabbit immunized against cobra or viper venom acts equally well against any of the other poisons, i. e., there is no specificity of action, as judged by the species of snake.

(3) The serum possesses not only neutralizing properties when mixed with the venom in a test tube, but possesses also marked immunizing and curative properties, i. e., poison injected after previous serum administration becomes powerless, and serum injected after previous poison administration neutralizes the effects of the poison in the animal body, even after the symptoms of intoxication have already set in. Naturally the effect depends on the degree of immunity of the serum giver and on the proportionate amount of serum used.

(4) The immunizing effect produced by serum injections is not so lasting as that produced by direct injections of the poison, i. e., serum injections are incapable of rendering animals "gifttest." Calmette alludes to other matters, but since these are of secondary importance and still debatable, and not directly related to the subject of this article, we must pass them over. There is, however, one point which must be mentioned, since it is one affecting the whole principle of serum immunization. He states that he has succeeded in producing a "Giftfestigkeit" by means of repeated intravenous injections of hypochloride of calcium, and that the serum of such "chlorinated" animals will neutralize, in the test tube, at least, the effects of cobra poison. Roux elsewhere mentions‡ that the serum of animals immunized against tetanus or rabies is capable of neutralizing snake venom and of protecting other animals against subsequent intoxication with cobra poison, and that rabbits vaccinated against rabies can withstand four to five times the lethal dose of cobra venom; and also that abrine serum will counteract the effects of cobra poison and cobra serum those of abrine. Calmette goes so far as to say that an animal vaccinated against abrine may acquire a relative immunity against diphtheria, ricine and anthrax. If this be so, we shall have to modify our views as to the specific action of antitoxic serum, i. e., the first principle of serum therapeutics. We require a number of control observations before we can accept these remarkable statements; partial contradiction they have already received from Germany,§ and the writer's own experiments, so far, at least, do not lend much support to them. So long, however, as the whole question of this new treatment, striking though it is in its results, is still a mystery to us, we cannot afford to push aside observations because they seem improbable, or because they are contradictory.

Calmette asserts also that the fresh serum of *Naja tripudians* (a species of cobra) possesses to some degree, a least, immunizing properties, and, as we shall see, Fraser† bears him out in this, by stating that fresh serum of poisonous snakes possesses strong antitoxic and protective properties, not only against their own

venom, but also against that of other species. D. D. Cunningham\* and the writer,† however, in India, invariably failed to obtain antitoxic or immunizing effects with cobra blood or serum, although the writer succeeded in keeping the effects of cobra poison in abeyance by means of the blood (or serum) of the *Varanus Bengalensis*, a large lizard which is naturally strongly resistant against cobra poison.

These are the chief results obtained by Calmette, and knowing the difficulties of working with such deadly poison as cobra poison venom is, and the innumerable failures which accompany it, the writer is able to appreciate the success of the French author, all the more since he himself failed while working on the same lines, where to succeed seemed simply a matter of course. Recently these French observations have received entire confirmation in their leading points by Prof. Fraser, of Edinburgh, and the writer may be forgiven for stating here that, though he took up the control of Calmette's work with strong bias against the latter, he felt himself forced, already before Fraser's communications appeared, to acknowledge the correctness of the work done at Pasteur's Institute, so far as the antitoxic and immunizing properties against cobra poison of serum obtained from animals treated with that poison are concerned. He has not, however, convinced himself that hypochloride of calcium can immunize animals, or lead to the formation of an antitoxic serum. Fraser's contributions, though merely confirmatory, are of great importance, since they contain unquestionable proof of the truth of what must have appeared to all, except a few shrieking "zoophilists," to be striking and surprising revelations. The credit, however, of the discovery of a cure for snake bite—in the laboratory at least—belongs solely to France.

Having discussed Calmette's work more fully, we can speak of Fraser's experiments in a few words; but thereby we do not wish to detract in any way from the merit which characterizes his researches.

Fraser‡ worked with venom obtained from the Indian cobra, three species of rattlesnakes (*Crotalus horridus*, *C. adamanteus*, and *C. durissus*), the copperhead (*Trigonoccephalus contortrix*), the Australian black and brown snakes, and an unidentified *Diemenia* (*Pseudechis porphyriaeus* and *Diemenia superciliosa*), the African puff adder, night adder, yellow cobra and "rinkas" (*Vipera arietans*, *Aspidelaps lubricus*, *Naja haje*, *Sepedon hemachates*). He immunized his animals by the usual method of minimal subcutaneous inoculations, or by feeding, against the venoms of some of the snakes mentioned, and then established (a) the strong specific antidotal properties of the serum of these vaccinated animals against the poison with which they had been vaccinated, and (b) the vicarious antidotal properties against the other poisons. This serum he obtained in a dry, pulverizable condition without any appreciable loss of antidotal power; but we can hardly forgive him the hybrid and barbaric name "antivenene" which he applies to it. He confirms Calmette's results in almost every point, so that there is no longer any doubt left as to possibility of a successful cure against snakebite, especially as, by both observers, the curative injection was shown to be efficacious when the symptoms of intoxication had already set in, and as the experimental animals used were highly susceptible to the poisonous action of serpents' venoms, while man is, weight for weight, much less sensitive than a guinea pig or a rabbit. True, Fraser has generally worked with comparatively small lethal doses; this possible objection is, however, met by Calmette's results, which were obtained with much larger doses, and which, therefore, allow us to judge favorably of the practical application of the serum treatment.

The final verdict must, of course, depend on the success or failure following the use of the serum in cases of snakebite, and it must be remembered that, striking though our laboratory results are with tetanus antitoxine, so far the success obtained with acute cases of tetanus in man is disappointingly small, as the writer has shown elsewhere.§ Yet here we have a rational method of treatment, and the promise of almost certain success; we must now look for facilities and opportunities of trying the cure. In France they have already begun to manufacture this antitoxic serum in larger quantity, and Calmette writes that he has immunized a horse, and is ready to supply the remedy; and Fraser also has larger animals under treatment. No doubt India will not delay in carrying out the necessary arrangements for procuring what, after all, will be an imperial benefit.

The vicarious action of the immunizing venom serum is surprising, and may find an explanation in the similarity of the physiological action of the various poisons used. They are all poisons which cause death by acting on the central nervous system, especially the medulla, the animal dying from respiratory failure with salivation, retching, etc. And it is quite possible that chemically similar poisons which, according to their action on the animal body, belong to one physiological group, have the same antidote. It would therefore be interesting to test the antitoxic cobra serum on the poison of the Daboia, which, according to Wall, Cunningham and others, differs essentially in its physiological action; for whereas cobra, crotalus and viper venoms are paralyzing, medullary poisons, the poison of Russell's viper produces very varying symptoms, in some cases convulsions, in others paralysis and asphyxia; in yet others violent convulsions, followed by paralysis. Daboia venom undoubtedly contains a substance capable of producing the most violent convulsions, especially in birds, their occurrence depending on the size of the animal and on the amount of poison injected.

It would, indeed, be more than a surprising revelation if a serum which is capable of acting as an antidote to a paralyzing toxin were also capable of neutralizing the effects of a toxin of opposite physiological action.

The vicarious antidotal action of venom serum must appear all the stranger and more contradictory if we remember that not all poisonous snakes are "gifttest" against the poisons of other different species. Wad-

dell\* has shown that the venom is neither a poison to the snake itself nor to members of its own species, but that cobra poison is fatal to some, if not perhaps to all, poisonous snakes. It will certainly kill the *Trimeresurus erythrus*, and in the writer's experience also the crotalus; while, according to Fayrer, the *Bungarus* readily falls a victim to the bite of a cobra. This being so, why should the antitoxic serum of an animal immunized against cobra poison be active against rattlesnake venom, when in an experiment recently performed by the writer, a strong and healthy crotalus succumbed to five milligrammes of cobra venom? Lastly, some writers, Fraser included, assume that the immunity of poisonous snakes against their own poison depends on self-immunization, called forth by swallowing their own venom, or by repeatedly inoculating themselves. This is highly improbable, if we remember that some of the innocent snakes are very resistant against cobra poison, as, e. g., the *Ptyas mucosus* and the *Tropidonotus natrix*, and also that, as the writer has shown, the *Varanus Bengalensis* is possessed of a marked tolerance, and that, according to Fayrer, other species of *Varanus* survive the bite of a cobra 24 to 48 hours.

Jourdain further gives a list of four innocent snakes which are immune against viper venom. In what manner are we to account for this immunity? Interesting observations on the poisonous nature of serum of innocent and poisonous snakes are also found in Calmette's paper of April, 1895, which, while rendering Fraser's theory still more improbable, do not assist us in clearing up the mystery. The explanation must be left to future researches; for the present we must be thankful for the promise which the researches of Calmette and Fraser have given us, of allaying an almost national calamity.—A. A. K., in Nature.

### ENGLISH PRISONS.

I WILL open my remarks on present punishment with a sketch of a modern cell. The bedding is stowed in military compactness in one corner, while the tin can, plate and Bible lie upon a shelf, and the plank bed rests against the wall in a nearly upright position. Flogging, which, I am glad to learn on inquiry, is comparatively rare in our prisons, is perhaps the severest form of chastisement, excepting capital punishment, which occurs in our country nowadays, and is only awarded for excessive insubordination or brutal assaults on the warders. The birch is composed of a bunch of short whips, the projecting points of which can accomplish a great deal in the way of suffering. The cat-o-nine-tails takes the form of a short handle, to which are bound nine long hard cords, each terminating in a formidable-looking knot. I have seen an article of this kind with little squares of lead at the ends of the thongs. Whichever sort of whip may be used, however, it is certain that the fellow enduring a thrashing receives, at each blow, nine long gashes, for the officials have a way of not only driving the thongs against the flesh, but also drawing them across the back immediately the cruel knots touch the man. Brine is afterward rubbed into the wounds as a healing agent, I am informed, but it really acts as a horrible and thoroughly brutal additional measure of pain.

The treadmill ranks next in order of severity, and, in connection with it, it is curious to reflect that it forms a practical example of making men earn their bread "by the sweat of their brow," for it really grinds the corn wherewith the prisoner's unpalatable brown bread is made.† Each man occupies a stall or compartment, and holds on by his hands to a rail situated in the upper portion. The wheel consists of a long series of planks attached to an axle, and passes through circular holes in the partitions for a long distance. The prisoner has to place one foot on the step which is uppermost when he alights on the scene, and assist in pressing the wheel downward until the next plank appears below the sloping board which conceals the top of the wheel. It is not permissible to place both feet together on the same step; and neither foot can remain longer than a few seconds on the wheel, for as the planks revolve downward their consequent sloping condition prevents such a chance of rest. Unless faintness or deliberate obstinacy intervenes, the man must remain suspended in this painful attitude, with but just the front half of each foot treading alternately with its fellow on moving, slippery boards. It is a significant fact that in large gaols good-conduct prisoners are continually parading the torture chamber (for such it assuredly is) with cans of water for the occasional drinking of the men when they have a moment's respite. Men have been known to fall fainting from their elevated positions.

The plank bed has been a much-talked-of article, but few people seem to be aware of its appearance. It is merely a few planks raised upon some cross beams and fitted with a kind of wooden pillow. It is portable. Every prisoner, unless certified by the doctor to be too weak in health to endure it, has to lie nightly, for a period of a month or more, on this bare hard bed, warmed with but a pair of sheets and a rug. When the hour of rest (†) arrives his wearing apparel is taken from him and remains out of his reach till morning, so that he has two very harsh alternatives to choose from. He must either lie in direct contact with the boards if he desires warmth above him, or he must, if he elects to soften his bed and lie on the rug and sheets, shiver throughout the night in almost a state of nudity, without the slightest protection from the cold.

The dark cell is a punishment less endurable than might be supposed. A sheet of iron pierced with holes for the admission of just sufficient light to enable the authorities to say that the cell is not in total darkness screens the window. The prisoner sentenced by the governor of the gaol to one, two, three or a longer number of days' incarceration, is confined by himself and has a bare plank bed to sleep upon and nothing but bread and water as food, generally speaking. There are two doors to the cell, the obvious purpose of this extravagance being the desire to cut the victim off as effectively as possible from all sounds, as well as light, and make his lot the harder to bear. I think

\* Sewall, *Journal of Physiology*: Kautschak, 1891, vol. xvi, Nos. 3 and 4; Phisalix et Bertrand, *Compt. rend. de l'Acad. d. sc. cxviii*, 1894, pp. 288, 326; Arch. de physiol. 5 ser. vi 3, 1894, pp. 597, 611; *Compt. rend. de la soc. d. biol.* 9 ser. vi, 1894, pp. 111, 124; Kaufmann, *ibid.*, p. 113, and Calmette, *Annales de l'Inst. Past.* 1894, vol. viii, No. 5, p. 281.

† *Lancet*, June 11, 1892. The uselessness of strychnine was previously demonstrated by the writer in his paper in the *Journal of Physiology*.

‡ *Annales de l'Inst. Past.*, 1894, No. 10, p. 723.

§ Ehrlich emphatically denies any such vicarious contraction with regard to strychnine and ricine (cf. *Deutsche Med. Wochenschrift*, vol. xvii, No. 44, p. 1218).

¶ *Lancet*, August 10, 1895, p. 370, and *Brit. Med. Jour.*, August 17, 1895.

\* Private communication.

† *Journal of Physiology*, 1892, vol. xiii, Nos. 3 and 4, p. 288.

‡ *Brit. Med. Jour.*, 1895; June 15, p. 1309-1312.

§ *Medical Chronicle*, May, 1895.

\* Scientific Memoirs by Medical Officers of the Army of India, 1890, iv, p. 59.

† It was adapted by Sir William Cubitt in 1817 from a similar contrivance used by the Chinese, and was first introduced into Brixton Gaol.

that it is a great shame that this punishment is permitted, for the reason hereafter advanced. Every one, I doubt not, is aware that if a person suddenly issues from a darkened room, in which he has remained for a lengthy period, and enters a lighted apartment, an unbearable pain in the eyes and consequent dimness ensues. Surely, then, a man's sight must be seriously, and, perhaps, permanently impaired, when, after a prolonged captivity in a dark cell, he is suddenly brought out into the light of day.

Convicts in the Michigan State Prison have many more favors than those of almost any other penitentiary in the United States, and it is the belief of the management of the institution that for this reason there are fewer outbreaks of lawlessness than are found elsewhere. Among the favors granted to them here is that of keeping and caring for birds. There are fully 600 feathered songsters in Michigan's principal penal institution, all owned and cared for by the convicts, and as soon as daylight approaches on bright mornings their sweet notes are heard in striking contrast to the natural feelings of their owners. Many of the most hardened criminals, from their general appearance and history, would not be expected to care for anything of a refined nature, yet they tenderly care for and caress their little pets. More than three quarters of the cells in the prison contain one or more canaries, and they are also found in various shops throughout the institution. During the day the cages are hung outside the cells to give the birds light and air, but as soon as the convict returns from work at night the cage is taken inside. This practice has been carried on in the prison for years, and the officials say that instead of any detrimental effect being noticeable, the little birds have proved a benefit, as they not only give the cells a homelike appearance, but they also wield a decided influence in the way of humanizing the most reckless and hardened criminal. Besides being permitted to keep the birds for the sake of their company and influence, the convicts are also allowed to raise them to sell, and many a shilling is credited to the accounts of the prisoners from this source. Of course the convict handles none of the money realized from the sale of the birds until he is discharged, but it is placed to his credit in the prison bank.—Minster Magazine.

[FROM KNOWLEDGE.]

#### THE COINAGE OF ROME.

By G. F. HILL.

THE coinage of Rome, and of those parts of the Italian peninsula which did not come most directly in contact with Greek civilization, offers a striking contrast with the coinage of Greece.\* Whereas, in the first place, the latter began with the more precious metals, Italy at first contented herself with bronze (aes) as her medium of exchange; for the coinage of silver and gold, though these metals were well known, was not introduced until comparatively late. And as Roman civilization generally was some centuries behind that of Greece, it is not until the middle of the fifth century that coinage, properly speaking, can at the most liberal estimate be conceived to have begun in Rome; while there are reasons for putting the commencement nearly a century later. Previously to the commencement of coinage proper, the medium of exchange in Italy, as in other parts of the world, had been cattle, values being reckoned in so many oxen or sheep. The transition from this system to the money system was made by the use of amorphous lumps of bronze (aes rude) which circulated by weight. Such pieces of metal cannot be called money, any more than their predecessors the sheep and oxen, and therefore as numismatists we are only secondarily concerned with them. It is, however, worth noting that long after aes rude had been superseded by coined money it was retained in use for certain special purposes. It was retained, for instance, together with the scales in which it was weighed, to perform a ceremony necessary to the validity of the transfer of certain kinds of property. It was also frequently devoted as an offering to various deities, in the localities of whose shrines large quantities have been found.

It is with the aes signatum (bronze marked with a design) that our description of Roman coinage must begin. Some authorities, as we have already said, refer the beginning of this coinage to the middle of the fifth century before Christ, and this view is based on literary tradition; but even if the literary evidence can bear the interpretation put upon it, it must always yield to the evidence of coins themselves. And a comparison with the coinage of the rest of the world proves conclusively that the earliest pieces which have come down to us belong to the fourth century, and by no means to its earliest years.

We meet at the outset with an important difference from Greek usage as regards the method of coinage. Greek coins were, almost without exception, struck with a die; but the bronze coinage of Italy was cast in a mould, and the reason is obvious. The small value of copper as compared with silver and gold necessitated the use of large masses of metal to represent high denominations; and to strike such large masses with a die requires skill and power which are difficult to provide even in modern times, not to mention the fact that few dies would stand the strain. The metal was, therefore, given the required form by casting, and even in later times the officials of the Roman mint retained the title of "commissioners for casting and striking bronze, silver, and gold." In some of the pieces projections at the sides of the coin mark the points at which the liquid metal entered the mould (Fig. B).

The earliest cast coinage took, for large denominations, the shape of oblong bricks of metal, weighing from four to five Roman pounds (Fig. A). Probably contemporary with these are the smaller pieces of the more convenient circular shape (Fig. B). This is what is known as aes grave ("heavy bronze," so called, of course, in comparison with the lighter coinage of later days). The large size of the early pieces necessitated a thick as well as a broad fabric. But with the gradual decrease in size of the pieces, which we shall describe later, we arrive at a fabric hardly differing from that of the Greeks. For about 260 B. C. the smaller bronze coins were struck instead of cast, and some

twenty years later the process of casting ceased entirely to be employed.

About the same time as the aes grave was introduced the extension of the power of Rome over the peninsula had compelled the Romans to adopt the customs of their South Italian neighbors, and issue coins in silver and even in gold. But it is characteristic of Roman conservatism that the first coins in these metals struck by Roman authority were struck, not for Rome itself, but for the subject states, or rather as war money, to be used in the wars waged by Rome against the Samnites, the Greek general Pyrrhus, and the Carthaginians. About 342 B. C., when the Romans began to interfere with the affairs of Campania, the coinage hitherto issued by the cities in that district

only a few mints were allowed to strike even in this metal, the largest series being those of Alexandria in Egypt, Antioch in Syria, and Caesarea in Cappadocia (Fig. 20 shows the sacred mountain Argæus, near Caesarea). The silver of these mints became rapidly debased, until it was no longer distinguishable from bronze. The actual bronze coinage of the Roman Empire may be divided into two classes. The first is that struck at Rome by the orders of the Senate (the ordinary "large brass" coins, marked with the letters S C—"by decree of the Senate"); the second is the money issued by the various cities of the provinces, from the Atlantic Ocean to the Euphrates. Of the vast quantity of bronze coins turned out by these mints, it is difficult even for the specialist to form any



FIG. A.—AES SIGNATUM, THE EARLIEST CAST COINAGE OF ROME.

was replaced by pieces of silver, bronze, and (a little later) gold, issued by the Roman generals and bearing the name of the Roman people (Figs. 6 and 7). Still, it was not until some seventy years later that Rome struck silver for her own use (260 B. C., Fig. 9). This date marks the practical cessation of the various independent coinages of Italy; almost all the cities now being compelled to issue only small change on their own account, and to use the Roman money for higher denominations. Gold still continued to circulate by weight, and indeed this metal was never reduced to a regular system of coinage until the time of Augustus. There are, it is true, instances of gold pieces being struck by the Romans. For example, besides the Campanian gold already mentioned there was a considerable issue of gold (Fig. 8) during the second Punic war (in the end of the third century); but this was made solely for the purpose of carrying on the war in Southern Italy, and must be regarded, like the Campanian gold, as "money of necessity" rather than as regular coinage. The gold pieces, again, struck by Sulla (Fig. 15, Head of Venus, and Cupid; reverse, trophies and sacrificial instruments) and Pompey the Great in the first century were also no regular coinage, but were probably issued for show, or for distribution as presents

conception; and a glance through a representative collection will do much to impress one with the fact that under the early Roman Empire the civilized world enjoyed a condition of material prosperity such as those who read only the history of the Roman court can never realize. After the time of the Emperor Gallienus (253-268 A. D.), the coinage shrinks considerably in amount, and there is no extensive series issued by any city on its own account, except Alexandria. We have now only the imperial coinage, issued not only in Rome, but in provincial mints, such as London, Trèves, Lyons, Milan, Nicomedia, Antioch, Alexandria. The number of these imperial local mints was further increased by Diocletian (284-305). From this time until the fall of the Roman Empire in the West in 476 A. D., there is no important change to chronicle, except the rise of the Byzantine coinage, which being an outcome of the breaking away of the civilized world from Rome, may well be left for consideration in connection with the coinage of Europe in the Middle Ages.

In the above sketch of the history of Roman coinage we have taken no account of the changes in the monetary standard. This, nevertheless, is a most remarkable feature, and must, at the risk of tedium, be



FIG. B.—LIBRAL AS, FIRST CIRCULAR COINAGE OF ROME.

The coinage of gold was strictly forbidden in provinces where Rome had anything to say. But as in Greece Alexander the Great had signalized the universality of his rule by enormous issues of gold, so the universal empire of the Romans was marked by the imperial metal being placed at the head of the coinage of the world. Alexander had not been able to prevent the various Greek states issuing gold on their own account, but under Roman rule the use of this metal was much more strictly reserved to the imperial exchequer. Some idea of the amount of gold issued by Julius Caesar and his immediate successors may be gathered from the fact that in a single hoard, buried seven years after his death, no less than eighty thousand pieces were collected.

The coinage of silver under the Empire was not so severely restricted as that of gold. At the same time,

dealt with in some detail. The Roman bronze coinage was based on the pound (libra) of bronze, and the mass of coined metal supposed to be equivalent to the pound was called as. The as was divided into twelve ounces (uncia), and the denominations (which were all, as we might expect from the practical Romans, marked with their value) were thus as follows:

As	= 12 uncia, marked with	I
Semis or half	= 6 " "	S
Triens or third	= 4 " "	••••
Quadrans or fourth	= 3 " "	•••
Sextans or sixth	= 2 " "	••
Uncia or twelfth	= 1 " "	•

There were also multiples of the as, such as the dupondius, quadrans, quincussis and even decussis, of

\*See "Coinage of the Greeks," in Knowledge, June, 1895.

2, 4, 5 and 10 asses respectively. And, at any rate later, there were divisions of the uncia.

As a matter of fact, no extant specimen of the so-called "libral as" (Fig. B) is of the full weight of the libra, and it is clear that no attempt was made to attain exactness in weight. The as then began

(trial as). About 250 B. C., the sextantal as (= two old uncies) was recognized. In the second Punic war a third reduction took place, giving the uncial as, and later still the standard fell one-half to the semuncial as.

Thus, in the course of some two centuries, the bronze standard of the Romans was reduced to one-

became more or less tokens: that is to say, they were given an arbitrary value, and their exact weight was, therefore, a matter of small importance.

The poorer a metal is, the greater is the tendency to use coins made of it as tokens rather than as pieces expected to realize their intrinsic value. A further explanation of the degradation is to be sought in the shrinkage which takes place whenever a cast is made. If the mould for one coin is made from another coin, the new coin, in cooling, will become slightly smaller than its model, and a third coin reproduced from the second will be smaller still.

The bronze coinage, which had been thus reduced to so insignificant a position, seems actually to have ceased about 88 B. C. It was not until the time of Augustus that the Roman mint again made a regular issue of bronze money, although generals like Julius Caesar and Marc Antony struck bronze in the provinces.

With regard to the silver standard, it is only necessary to say of the Roman coins struck for the Campanian cities, that they conformed to the Greek standard already in use in that district, the stater (Fig. 7) weighing 112 grains and under. The unit of the silver coinage of Rome itself was the denarius (Fig. 9, weighing  $\frac{1}{16}$  of a pound, equivalent to 10 asses and marked with X); and the small denominations were its half (quinarus, V) and quarter (sestertius,  $\frac{1}{4}$  asses, represented by IIS, afterward written HS). These marks of value cease to appear on the silver coinage about 90 B. C.

In the Hannibalian war, when the as underwent its third reduction, the value of the denarius was slightly raised by lowering its weight from  $\frac{1}{16}$  to  $\frac{1}{18}$  of a pound of silver. At this weight it remained for more than three centuries, and the coins were never alloyed. At the same time the Roman mint openly indulged in the practice of issuing a certain number of denarii of bronze plated with silver. These were mixed with the good coins in each issue, and there was no attempt to conceal the fact; and as the treasury was obliged to accept its own bad coin, these issues stand exactly on a level with the paper money of our own times, except in so far as they made the way more easy for the private forger. Besides the denarius we have also to note the victoriatas (so called from the figure of Victory erecting a trophy on the reverse; Fig. 10). This was first issued about 227 B. C., for circulation in Southern Gaul, Northern Italy and Illyria and was based on a unit equivalent to three-quarters of a denarius. But it soon went out of use again, its type being adopted for the quinarus. The quinarus itself and the sestertius both ceased before long to be issued regularly.

The Roman gold coins (Fig. 8) which were struck during the Hannibalian war also bear marks of value, but in terms of the sestertius, not the denarius. Thus:

↓X	=	60 sestertii	=	15 denarii
XXXX	=	40 "	=	10 "
XX	=	20 "	=	5 "

We have already alluded to the gold coins struck by Sulla and Pompey. Coins similar in character to these were struck by Julius Caesar. Augustus issued an aureus (Fig. 10) equivalent in value to 25 denarii, at the weight of 40 to the pound of gold, and along with it a half-aureus. He also commenced a fresh issue of denarii, but adhered to the usual weight. His reforms in the coinage of small change were important. A large piece (Figs. 24, 25, 27, 28) called the sestertius (but wrongly, for it was equivalent to 4 asses) was issued, with its half (dupondius) and quarter (as), and smaller denominations. The denarius being equivalent to four sestertii was now equivalent to sixteen asses. The small change was merely a token money, the as being nearly equal in size and weight to its double, the dupondius; but while the latter and the sestertius were made of yellow brass or orichalcum (copper alloyed with zinc), the as and smaller divisions were made of pure copper.

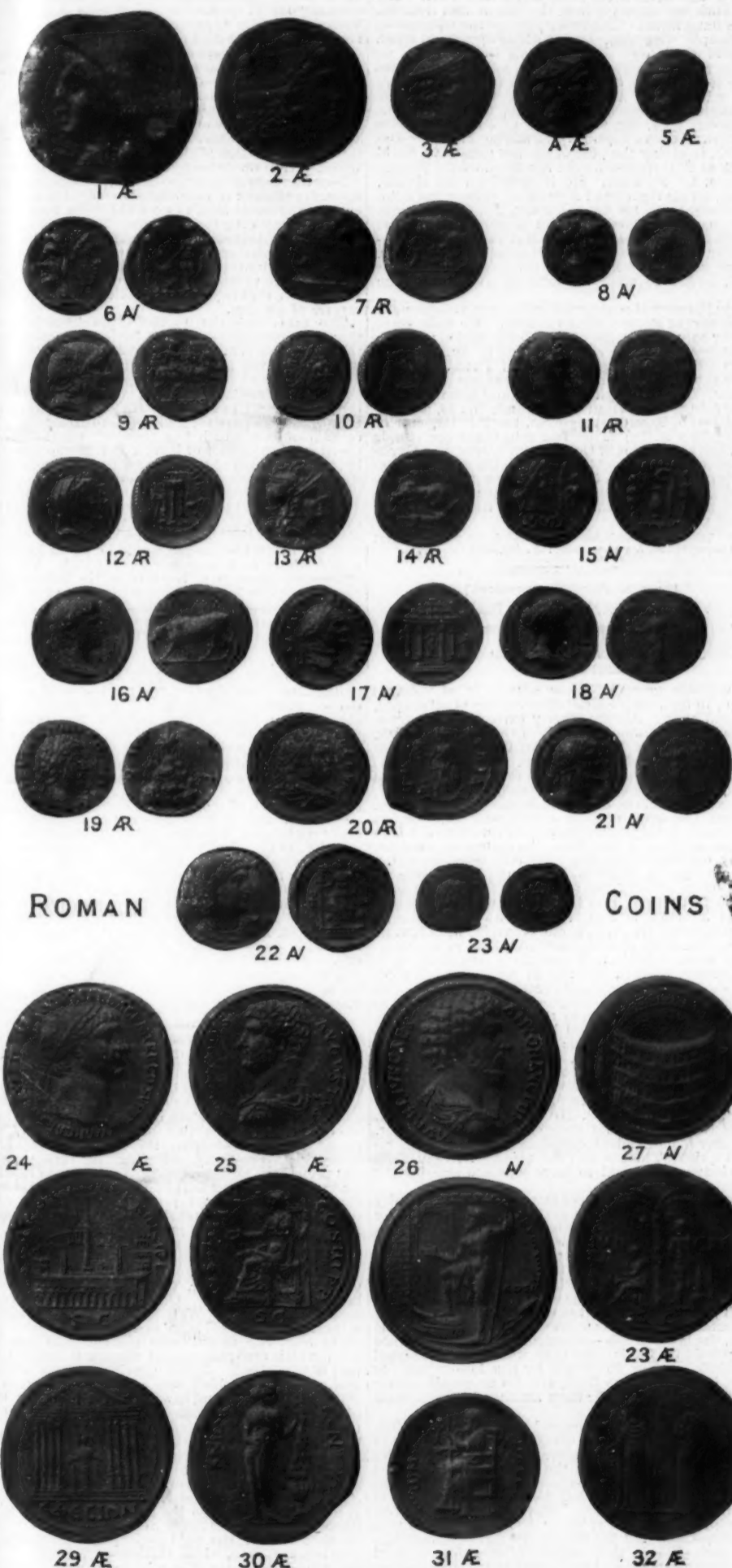
Such was the beginning of the Imperial coinage. But the degradation to which Roman coinage seems to have been peculiarly susceptible soon made itself apparent. By A. D. 215 the aureus was worth only  $\frac{1}{4}$  of a pound of gold, and the denarius only contained 40 per cent. of pure silver. The Emperor Antoninus (commonly known as Caracalla) now introduced a new silver piece (argenteus Antoninianus, Fig. 21), worth half as much again as the denarius, from which it was distinguished by having the emperor's head in a radiate crown (instead of laureate), for the empress's bust on a crescent.

The debasement went on till the time of Diocletian, who, in A. D. 296, made a clean sweep of all existing coinage, and issued a fresh series: An aureus of  $\frac{1}{4}$  of a pound, and a silver centenionalis. The debasement of silver had driven the copper coins out of existence. Diocletian now issued two kinds of copper coins, the follis and the copper denarius. Of later changes we need only note that Constantine reduced the aureus to  $\frac{1}{4}$  of a pound, calling it the solidus (Fig. 22), and issued two kinds of silver, the miliarenis (=  $\frac{1}{4}$  solidus), and its half, the siliqua.

We may now pass to the consideration of the types which occur on the coinage of which we have sketched the history, and of its artistic value. The latter is, at most periods, comparatively small; for the Romans were not an artistic people. Indeed, the hard, matter-of-fact way of looking at life, which was characteristic of this race, made it at the same time especially fitted to attain the dominion of the world and unfitted to entertain the artistic ideals of the Greeks. In one form of art they did attain a very high degree of excellence—and that is portraiture. But this is precisely the branch of art into which the ideal element least enters. Even so, it was long before the Romans found, so to speak, their artistic vocation.

The types of the early coins are such as we might expect from our study of the Greek series: animal types, such as the ox (possibly a reminiscence of the old medium of exchange, Fig. A), or the elephant (an allusion to the animals employed by the Greek King Pyrrhus, in his war against the Romans in the early years of the third century); or, again, types with a religious significance, such as the eagle standing on a thunderbolt (both attributes of Jupiter). It is not certain which of these early pieces are to be given to Rome, and which to other cities of Italy, except in the cases where the word Romanum actually occurs on the coin.

The as grave series (Figs. B. and 11f) presents us



THE COINAGE OF ROME.

badly, and went through an extraordinarily rapid process of degeneration.

The exact stages of this process are not certainly fixed, but they seem to have been somewhat as follows:

The first great reduction took place in 260 B. C., when the as was reduced to a third of its former weight

twenty-fourth its original weight. (Figs. 1-5 represent this gradual degradation, the sextans being selected as typical). This degradation, which is without parallel in the history of coinage, is only partially explained by the tendency of all heavy coinages to fall in weight. It is probable, nay, more than probable, that soon after silver came into use, the bronze coins

with a somewhat uninteresting set of types. The type of the reverses of all the denominations is uniformly the prow of a vessel of the kind used in the fourth century—a proof, if needed, that these coins did not come in before that time. The various denominations are distinguished, in the first place, by the marks of value (sometimes on both sides) we have already described, and in the second by the type of the obverse. The as (Fig. B) bears always the double-head of the god Janus (cp. Fig. 6); the semis the laureate head of Jupiter, the triens that of Minerva wearing the helmet, the quadrans that of Hercules in the lion's skin, the sextans that of Mercury in his winged hat (Figs. 1–5), and the uncia that of Minerva or Roma herself. These coins are of a style which belongs not to the primitive artist, but rather to a people who care little for the artistic value of the things they handle. The republican Roman, in fact, cared no more for the beauty of his coins than does the modern Englishman.

The first gold and silver coinage (Figs. 6 and 7) struck, as we have seen, for use outside Rome, bears, like some of the as signatum, the name of the Roman people. As a rule, the types are not of sufficient interest to detain us, since we have seen better things of the same kind done by the Greeks.

Fig. 6 shows two soldiers taking an oath over a slain pig. It is interesting to note on No. 7 an early, if not the earliest representation of the Roman national legend, a she wolf suckling the twins Romulus and Remus.

After the reduction of the as, the copper as well as the silver, now actually issued in Rome, bore the name of the city. The most frequent type of the reverse (the obverse bearing the head of Rome) on this early silver is the heavenly twins Castor and Pollux, whose appearance at the battle of Lake Regillus was one of the most popular of Roman legends. The heroes are represented (Fig. 9) on horseback, charging the enemy; they wear conical caps, and above the head of each is a star.

The second and first centuries before Christ form the last period of republican coinage. The characteristic of this time is the appearance on the coins of the names (at first in abbreviated form, and then gradually at greater length) of the officials charged with the issue of money. These names, which, however, cease about 36 B. C., enable us to ascertain with comparative exactitude the dates at which individual pieces were issued. The types, at first uniform, first began to be varied in 100 B. C., and from this time they have a personal significance; that is to say, they relate to events in which the ancestors of the moneyers, less frequently the moneyers themselves, took, or were supposed to have taken, a part. Thus a denarius, struck between 134 and 114 B. C., by Marcus Caelius Metellus (Fig. 11) shows on the reverse a Macedonian shield, with an elephant's head in the center, the whole surrounded by a laurel wreath.

This is, in the first place, an allusion to victories won by Lucius Caelius Metellus in Sicily in 250 B. C. Elephants were a formidable feature of the army of the Carthaginian Hasdrubal, whom Metellus defeated at Panormus (Palermo), and the captured animals figure on the coins of his descendant, as they had figured in his own triumphal procession. The shield, on the other hand, must refer to the victories won by another Caelius Metellus in Macedonia from 148–146 B. C. These "family" denarii were imitated by the Italian generals who headed the revolt against Rome, known as the Social War of 91–88. The obverse of Fig. 13 bears a head resembling that of Roma on Fig. 9, but with the legend Italia.

On the reverse of another coin (Fig. 14) are a bull trampling on the Roman she wolf, and the name of the general, Gaius Papilius (in the local alphabet). The later denarii of this period bear the name, not only of the moneyer, but of his superior officer. Thus a coin (Fig. 15) probably struck in Macedonia under Brutus, the murderer of Caesar, bears on the obverse the name of his subordinate, Lucius Sestius, and the head of Liberty, on the reverse the name of Brutus himself and sacrificial instruments. The improved style of this period is partly due to the fact that many of the pieces were struck in Greece and the dies engraved in all probability by Greek artists. Rome could no longer resist the influence of Greek art, and with the commencement of the empire there was a great influx of Greek workmen into Rome.

Now begins a splendid series of coins with unsurpassable portraits of the rulers of the world (Figs. 16, Augustus; 17, Vespasian; 18, Faustina II; 24, Trajan, reverse, the Forum; 25, Hadrian, reverse, Justice). For about two hundred and fifty years the art of portraiture maintains a high level, rising, perhaps, highest in the time of Hadrian (Fig. 25, reverse, Justice) and his immediate successors. The reverse types are often of great interest. No. 27 gives a view of the Coliseum; No. 28 shows Judaea seated under a palm and guarded by a Roman soldier (referring to the subjugation of the Jews by Titus).

The increased diameter of the copper and brass coinage reintroduced by Augustus provided room for an art which is almost medallion. What are called Roman medallions (Fig. 26, Marcus Aurelius, reverse, Neptune) were pieces of an even larger size, struck in all three metals, and probably serving for memorials and not for currency.

Augustus had abolished the board of moneyers in B. C. 3. The right of coinage in gold and silver now resided in the Emperor, whose portrait and title appeared on the obverse of the coins. The details given in the titles often enable us to date a coin more or less accurately. Thus No. 34 was struck, not before the fifth consulship of Trajan (A. D. 103), but before A. D. 112, when he was consul for the sixth time. After the third century, however, the titles cease to be given in full. As regards the bronze coinage of the second or provincial class, it is to be noted that the cities struck large numbers of coins without the head of the Emperor, but with some ideal type, most frequently the head of the Roman senate, of their own town council or of the "People." The reverses of the coins were occupied by a great variety of designs, allegorical, mythological, historical, architectural or merely ornamental. The interpretation of these designs in the case of the Greek provincial coins is most important as illustrating the life of the time. A vast mass of information of historical importance relating to the religion,

politics and external aspect of the Greek cities, is being gradually gathered from this interesting, though not very artistic series.

We may notice here four coins. The first (No. 29) was struck at Ephesus and represents the cultus statue of Diana of the Ephesians in her temple. The idol is mummy shaped up to the breast, and wears on her head a tall head dress from which falls a veil. Her arms stick out sideways from the elbows and from the hands hang fillets. The lower parts of the columns of the temple were decorated with sculptures in relief, traces of which may be perceived. In the gable we also see a representation of the pedimental sculptures of the temple. No. 30 was struck at Cnidus in Caria, a town adorned by a famous statue by Praxiteles of Aphrodite going down into the bath. The work of the coin is very poor, but is valuable in connection with the known Roman copies of the statue in Rome and Munich, as giving the pose of the lost original. No. 31 (struck at Elis) represents the famous statue of Zeus at Olympia, by Phidias. He is seated on his throne, bearing on his right hand a statue of Victory and holding his scepter in his left. Finally, No. 32, of Samos, shows us the Goddess Hera in a guise not quite so hieratic as the Ephesian Diana, but still formal. Beside her stands the Goddess Nemesis. These coins, though we cannot here discuss their types in greater detail, suffice to show the interest attaching to the class.

After the second century all pretense to artistic merit on the part of Roman coins vanishes. We have space here for only three coins of this later period: No. 21, of Allectus, the usurper, who reigned in Britain from 293 to 296 A. D. (reverse, figure of Peace, carrying flower and scepter); No. 22, of Constantine the Great (reverse, Victory carrying a trophy and palm branch; in the field the Christian monogram); No. 23, a triens (½ solidus) of Romulus Augustus, the last emperor of Rome (475–6 A. D.) This last coin bears the simple cross, but the solidus of Constantine shows the Christian monogram in combination with the distinctly pagan type of Victory, illustrating the fact that the transition from paganism was not a complete and sudden change, but a gradual grafting of the new ideas on the old stock.

NOTE.—The various metals are distinguished in the plate as follows: A, Aurum, gold; AR, Argentum, silver; AE, Aes, bronze or copper.

[FROM THE BOSTON COMMONWEALTH.]

## THE VOLCANOES OF HAWAII.\*

By EDWARD EVERETT.

### III. VOLCANIC ACTION AND ITS PECULIARITIES IN THE ISLANDS.

THE whole group of these islands is of volcanic origin; in fact, they consist of volcanoes of all shapes, sizes and kinds. All are utterly extinct, except those on the largest and most easterly of the islands, Hawaii. Of these volcanoes, Kohala, about 6,000 ft. high, Mauna Kea, 13,805 ft. high, are extinct. Hualalai, 8,275 ft. high, had its last violent eruption in 1891, accompanied by a profuse discharge of lava running to the sea; Mauna Loa, 13,675 ft. high, and Kilauea, 4,040 ft. high, the last two remaining in action with more or less vigor continuously, and occasionally throwing out lava streams—seldom of late from the craters themselves, but by outbursts from the mountain sides, occurring from a height of 12,000 ft. (on Mauna Loa) to heights lower down or near the sea level. There have been nine such eruptions from Mauna Loa since 1832, occurring at intervals of 3 to 11 years. As an instance, a few particulars are given of one occurring in 1859, when an eruption burst from the mountain side, at an elevation of about 10,500 ft. in a fountain of lava 400 ft. high. The stream from it, varying in width up to 3 miles wide and of unknown depth, reached the sea 33 miles distant in 8 days. It commenced in January and was still flowing into the sea in the November following. The volume of lava ejected in this eruption was estimated at 28,580,000,000 cubic feet, and that of another eruption, occurring in 1854, at 38,096,000,000 cubic feet.

The dome of Kilauea lies on the side of Mauna Loa, and their craters are only about 20 miles apart, though Mokuawe'owe'o, the crater of the latter, stands 9,500 ft. above that of Kilauea. In their times of action, these two craters do not sympathize with each other. One may be in violent eruption while the other remains quiet. Though so near neighbors, they seem quite independent and to have separate and distinct sources of action.

In contemplation of these facts, the great difficulty of accounting for volcanic action in general, and for that of these islands in particular, becomes strikingly apparent. On a cursory view, it seems easy to account for the outflow of lava and the upbuilding of mountains by successive layers of the cooled product, on the theory of a wholly or partially fluid interior of the globe, and on a shrinkage of the crust upon it, by which portions of the melted material are forced above the surface. But if such presumption were the true cause, the law of fluids—or hydrostatics, if such a word is applicable to fluids other than water—would compel the whole outflow to escape by the lowest vent, or vents, if on the same level, and no mountain crater could be built up higher than another by such cause or process.

In the case of Mauna Loa and Kilauea, in close juxtaposition, the same law would cause the column of lava in Mauna Loa, lying above the level of the crater of Kilauea, to flow out at the latter orifice, provided there was any internal communication between the two volcanoes, or that they derived their supplies of lava from the same source. The fact that Mauna Loa will support a column of lava 9,500 ft. higher than that in Kilauea, and that the two craters do not sympathize with each other in their periods of eruption, is proof that their existence and continued eruptive action depend on other circumstances and causes than those referred to, and that each crater must have its own separate and independent supply of lava.

Dana, in his valuable work on *The Characteristics of Volcanoes*, says: "The origin of volcanic heat, the source of lava columns beneath the volcano, the cause of the ascensive force in the lava column, are subjects on which science has various opinions and no positive

knowledge." There seems to be a general agreement, however, among scientific men, who have studied this subject, that the presence of water in the lava, made manifest on its discharge as steam, is the principal cause of the explosive eruption from volcanoes, whether a mere accompaniment of an otherwise quiet overflow at Kilauea, causing the immense fountains of lava 600 to 800 ft. high near the summit of Mauna Loa, the shooting out of pumice or other loose material from Vesuvius, or the blowing off of the whole top of a mountain into fine dust as at Krakatowa.

But it is a question in dispute, How does the water get into or become intermixed with the lava? In several places in Dana's work, he favors the idea of the direct entrance of water into the ascending column of liquid lava, either through fissures or channels existing in the substance of the mountain, or by capillary attraction. The water being that falling as rain upon the exposed portion of the mountain or the sea water which bathes the submerged base beneath the waves.

Now there are at least two objections, either of which appears sufficient to invalidate the supposition of the entrance of water into, or even obtaining near contact with the ascending lava column. The first of these is the high temperature of the lava. Presuming there were any crevice open by which water in any manner could gain admittance, it would be at once driven out again by the volume of steam formed. Also there is no evidence that capillary attraction can act at temperatures of ignition.

The other objection to the supposition is the immense preponderance of the hydrostatic pressure in the lava column, at all levels, over that of the surface water, or of the sea water at any depth. Soundings have shown that the ocean depths in the vicinity of these islands are 2,000 to 3,000 fathoms. The tops of the two higher mountains on Hawaii, therefore, stand near 31,000 ft. above their bases on the sea bottom. A column of lava which has risen to near the point of overflow at the crater of Mauna Loa, the specific gravity of the lava being taken at about 2.1–2.2 times that of water, would have at the sea level a pressure of 8,400 lb. or nearly 4.1–5 tons per square inch, and at the depth of the sea bottom, as above stated, a pressure of 33,635 lb. or about 16.2–5 tons per square inch; while the pressure of the sea itself at an equal depth or about 17,325 ft. below the surface, would be about 9,874 lb. or a little short of 5 tons per square inch. Thus the hydrostatic pressure of the lava at the bottom of the ocean would be 3.1–3.3 times as great as that of the sea at an equal depth. It is difficult to imagine the entrance of water against this excess of internal pressure, especially when to this is added the effect of the intense heat of the lava.

In a somewhat inconspicuous manner, and as if he did not consider the suggestion worthy of further investigation, Dana says: "Another source of water vapor recognized among writers on volcanoes is the deep subterranean region which supplies the lavas. Further, if the fusion has been produced by the melting, through earth movements or otherwise, of pre-existing rocks, the moisture of these rocks (perhaps 2 per cent. of their weight) would be a source of rising vapors."

Herein, it appears to the writer, lies the most probable explanation of the source of these enormous expansive forces. And it is not unscientific to presume that rocks containing moisture, either mechanically intermingled, or chemically combined as in many salts and other crystalline forms, have been, by the folding of the crust of the earth, so depressed to immense depths, without change of composition; and that when this material has been subsequently subjected to the internal heat of the earth, the contained water, though still imprisoned, has been converted into vapor with an expansive force capable of producing the volcanic effects exhibited in the Hawaiian Islands and other volcanic regions of the earth. This hypothesis is not incompatible with the supposition that the several volcanoes have independent sources of action.

### IV. ASCENT TO THE EXTINCT CRATER OF HALEAKALA.

Maui is the second in size of the islands of Hawaii. It has a mountain at each end and a low central plain connecting them. I had been staying at the home of a cousin at the foot of the mountain opposite to Haleakala, with that mountain in full view, looking like a smooth rounded hill with a base very broad in comparison with its height, the summit being about thirty-five miles away. During the three weeks I had been there, an unprecedented rainfall (the rain gage showing in one day a fall of 6 inches) rendered the roads almost impassable and prevented my going about to much extent, or reacquainting myself to horseback riding, which I had not practiced for many years.

On March 26, 1890, the roads having become firmer, my cousin took me in his buggy about eighteen miles on my way and partly up the mountain, and leaving me at the house of Mr. Thomas Gulick, he returned home with his team. On the way we had passed through the towns of Wailuku and Kalui, the latter a seaport where several large vessels were loading with sugar from the neighboring plantation of Spreckelsville, which occupies several thousand acres of that part of the island. I had previously gone over the vast sugar mill, which was admirably arranged for efficient operation, and saw one huge converter capable of turning out 110 tons of sugar per day. The cultivation of the cane is limited to the lands which can be irrigated by the mountain streams, which have been conducted to the plantation at enormous expense.

Armies of Chinese perform the labors of cultivation, assisted by the steam plow. In one large field we saw six large traction engines engaged in dragging gangs of plows to and fro over the land. The engines propel themselves along the roads and on to the headlands on each side of the field to be plowed, one opposite another, and then, while stationary themselves, drag the plows by means of a wire rope about 400 yards long, wound on a windlass driven by the engine. The engines, after each bout, advance themselves the required width of furrow, and the plows are then dragged back by the engine stationed at the other end. The plows tore through the chocolate colored volcanic soil with titanic force, leaving it in a fine state for further tillage.

Above the cane fields were fine land, with farms and ranches, and excellent grass lands where many cattle were raised and fed; but as a greater elevation

\* Continued from SUPPLEMENT, No. 1039, page 16601.

was reached the land became rougher and more broken, with rocky ledges and gulches.

I found Mr. and Mrs. Gulick, my hosts, very agreeable people, and their house, where I passed the night, finely situated on an elevation of over 2,000 feet, overlooking the western end of the island and the bays on each side of the low central portion. In the morning a saddle horse was sent for me, which carried me about a mile to the village of Mukawao, to the house of Mr. Loring Andrews, who was to act as my guide up the mountain, for which service he was very efficient, having passed much of his life in the vicinity, and accompanied many parties to the crater, besides going on hunting excursions after wild goats, turkeys and other game.

After a short delay we started on the ascent, Mr. Andrews mounted on a fine mule, myself on one of his horses, and a native man, carrying provision for ourselves and the animals, on another horse. We rode, gradually ascending, six miles to Olinda, a name given to a small frame house belonging to a wealthy sugar planter, and used for occasional residence in warm weather, of which Mr. Andrews had procured the keys. Arriving there shortly after noon, we refreshed ourselves with a cold luncheon and resumed our ride about 2 P. M. From Mukawao for a mile or two was a wagon road, then changing to a track or bridle path, getting steeper and more rugged as we ascended, and the actual distance much lengthened by the necessity of zigzagging to get over the very steep places.

As we neared the summit, the gulches increased in number and in depth, and masses of upheaved lava rock became more prominent. Besides this, the lesser obstructions of gulches, loose rocks, etc., in the path, made it frequently less dangerous and more agreeable to strike out a fresh trail for ourselves. Timber of any kind was not abundant on the mountain, but we saw numbers of dead koa trees, this species of valuable hard wood having become, from some unknown cause, nearly extinct over the whole island.

Vegetation diminished in quantity and luxuriance as we went higher; then dwarf shrubs and coarse grasses alone held possession, till near the summit, where none survived. On the way, we passed through a stratum of cloud, above which the atmosphere was remarkably clear and the sun shone hot and bright, though the temperature was lower, and as night approached, became quite cold.

The summit was reached at 4:30 P. M., and alighting at a place where an overhanging rock gave a partial shelter from the northeast wind, we ascended a few feet further between ridges of lava. Then, to my astonishment, I found myself on the very brink of the enormous crater, at an elevation of 10,030 feet above the sea level.

Before me was a chasm 2,000 feet in depth! Its form was exceedingly irregular and cannot be easily described, but as seen from our position on the western side, a wall of rock and debris, the nearest point of which was three miles from us, extended easterly and beyond the crater proper, formed one side of a channel, a mile or more wide, through which an enormous flow of lava must in former times have burst out on its way to sea. On the other side of this wide channel was a mountainous rock, forming the eastern end of the crater, being 7 miles distant from the place where I stood, and about 300 feet less in height. The northern side of the abyss was similar in formation and if possible more irregular, and was broken by another wide channel through which lava had flowed out.

The remaining side, on which I was, was mostly concealed from view by projecting rocks, which also left the profundity of the depth before me to the imagination. Near by, however, was a slant of loose material lying as steep as its earth and stones could remain in place and looking like an immense toboggan slide, reaching from top to bottom of the fearful depth. There was a difficult path to the bottom, in a recess which could not be seen from my position.

The rocky edges bounding this great crater, exceedingly irregular both in plan and elevation, would require a journey of 27 miles to surround them. The two great channels, before mentioned, must have been opened simultaneously by the pressure within the crater, and the whole liquid contents, carrying with it much of the solid crust, which together, at a low estimate, may be put at four to six cubic miles in volume, must have burst forth in one tumultuous rush on its way to the sea.

Several other extinct craters on the islands, notably that of Eeka, on the western end of the same island, Maui, show similar though single channels by which their contents have been discharged; and from the probability that such volcanic eruptions were accompanied by violent seismic convulsions, it appears more likely that the discharges took place in one grand outburst—to which the consideration may be added, that pressure for outburst was greatest only when the lava had attained its greatest height, and was in its most highly heated and liquid condition, rather than to suppose the channels to have been gradually worn, as if by something like glacial action, to which, however, some of these outlets bear considerable resemblance.

Reflecting on what has evidently occurred on this mountain, Haleakala, the mind turns to what may possibly happen on Mauna Loa, 4,000 feet higher than this one. The walls of the latter mountain are evidently becoming weaker, for the lava no longer rises and overflows from its summit crater, by which process the mountain was originally built up. But now, when the lava rises within the mountain to a sufficient height, it finds the weakest place and bursts out somewhere on the side of the mountain. It is a singular fact, which may be noted here, that eruptions occurring below the crater do not break out twice in the same place, the orifices being seemingly sealed up when each several discharge is exhausted.

The floor of the great crater was occupied by a number of volcanic cones, miniature craters when compared with the enormous cavity containing them. Owing to the vast time which has elapsed since these were active volcanoes, and the disintegration of their lavas which has been constantly going on since, they look from above like heaps of sand, with smooth and rounded outlines, having cavities in the center and gaps where the lava had run out from their craters. The unoccupied bottom of the great crater was also, as seen from our position, apparently of sand, with

occasional points or ridges of lava cropping out. The color of the lava sand varied from dull black through many shades of red and yellowish brown. At the bottom, beneath where we stood, were some dark masses looking like bowlders which had fallen from above, but I was assured they were the tops of trees. In some places also were bunches of wiry grass, but with these exceptions, the crater appeared utterly barren, and a more dismal scene, particularly when the shadows of evening gradually extended themselves over the abyss, could scarcely be conceived.

The enormity of the masses and spaces gradually grew upon the comprehension, and an idea of such magnitudes can only be conveyed by comparing some of the features with objects of known dimensions. For instance, the largest of these cones within the crater was stated to be between 700 and 800 feet high, and several others nearly approached such dimensions. Such mounds would bury the Washington Monument, or the biggest of the Pyramids of Egypt, out of sight; while a person standing on top of a tower, rising from the floor of the crater to a height twice that of the Eiffel Tower in Paris, would be scarcely able to look over the edge of the crater.

Exterior to the crater, the panorama from this grand elevation was a magnificent sight, and although I did not see the sun rise, I witnessed a brilliant sunset, which was the next best thing. The stratum of cloud we had passed through while ascending hung 2,000 to 3,000 feet below us and concealed nearly all of the island we were on as well as its neighbors. A portion of the ocean was seen glistening under the rays of the setting sun, like frosted silver, and was flecked here and there with specks of vapor, resting apparently on its bosom. Looking toward the island of Hawaii, the whole of its lower elevations were enveloped, like those of Maui, in cloud. But peering many thousand feet above the line of vapor were seen as distinctly as though they were not twenty miles away the summits of the volcanoes Mauna Kea and Mauna Loa—each nearly 14,000 feet high, and Hualalai, over 8,000 feet—the two former having each a slight mantle of snow. The actual distance of these mountains from our point of observation was not far from 50 miles. The clearness of the atmosphere above the cloud line, both outside and inside the crater, was very remarkable.

Having fed our animals, and cooked and eaten our own suppers, we commenced our descent of the mountain at 6:30 P. M. As daylight waned, a bright half-moon in a measure supplied its place. The imperfect light was so far advantageous as it concealed until safely past the difficulties and dangers of the way. Fortunately I was well mounted on an easy-going, surefooted animal possessing every requisite for rough mountain work, for at times the angle of descent was so great that the cant of the saddle would touch my back and the head of the horse almost disappear from sight; yet not a misstep was made, and I should not have known what bad places I had been through had I not seen them on the ascent by daylight.

We arrived at Olinda at 9:30 P. M.

## THE DISTINCTION BETWEEN ANIMALS AND PLANTS.

By J. C. ARTHUR.\*

THE animal kingdom and the vegetable kingdom were not sharply distinguished in the days when science was young, some two or three centuries ago, when even learned men believed in the Scythian lamb,† that grew on the top of a small tree trunk in place of foliage, and in the wonderful tree of the British Isles,‡ whose fruit turned to birds when it fell on the ground, and to fishes when it fell into water; and the two kingdoms are not sharply distinguished to-day, when learned men do not agree upon the systematic position of the Myxogastres and other low forms, some going so far as to assert that many of the simple organisms are on neutral ground, belonging no more to one than to the other kingdom. Dr. Asa Gray§ once said that "no absolute distinction whatever is now known between them. It is quite possible that the same organism may be both vegetable and animal, or may be first the one and then the other."

So numerous have been the vain attempts to find some character of universal diagnostic value that it seems rash indeed to make another trial. But, in case of failure, no harm will be done, even if no advance has been made.

In all attempts, so far as they have come to my notice, the characters selected to distinguish the two kingdoms have been physiological, and not structural. Yet, in the classification of plants among themselves, or of animals among themselves, the characters of acknowledged value are drawn from structure, and physiological distinctions are only considered when the organisms are very minute or simple, like the bacteria and yeasts, or for some other exceptional reason. It seems, therefore, highly illogical to accept a purely physiological character as fundamental for separating the two kingdoms.

On this ground we would discard Linnaeus' classification: Lapidæ crescent, vegetabilia crescent et vivunt, animalia crescent, vivunt et sentient; and that of Haeckel\*\* who accords the chlorophyll function to plants and not to animals; and that of Sedgwick and Wilson†† who find the sole characteristic of animals to be dependence upon proteid food; and also that of Dangeard‡‡ and Minot§§ who distinguish the two kingdoms by the manner in which the food, or food material, is taken into the organism. There are also characters, for which I need cite no authority, that were advocated at different times in the past, which

have since been discarded for lack of universality, such as a carbon dioxide respiration in plants and an oxygen respiration in animals, that plants exclusively convert inorganic matter into organic matter, that plants alone produce chlorophyll, or cellulose, or starch, etc.

In attempting to distinguish animals and plants by means of definite characters, there is another point that needs attention. Primary characters are to be drawn from the mature condition of the organism, and not from the reproductive or the immature state. This is such an obvious proposition in the ordinary classification of animals or plants, that it seems strange that in diagnosing the two kingdoms it should have been entirely overlooked. There are remarkable similarities in methods of reproduction among plants and animals, not only in the processes, but in the external means for protection and in the methods of dissemination of the reproductive bodies. Especially is this true of non-sexual reproduction among the lower orders. The reproductive structures are sometimes very elaborate, and the organism in that state often attracts more attention than in the vegetative condition, as in the case of the Myxogastres. It is obvious that the individual is the object that we are studying and classifying, and therefore the most fundamental of characters should apply to the individual—the vegetative organism—and not to the mode by which a succession of individuals is maintained.

The following definition of plants and animals is suggested as meeting the requirements of the conditions of classification mentioned above:

Plants are organisms possessing (in their vegetative state) a cellulose investment.

Animals are organisms possessing (in their vegetative state) a proteid investment, either potential or actual.

The organism may be a cellular body with the investment extending to each protoplasmic unit, as is usual in plants, or it may be a cœnocyte body with the investment extending only to the compound units, as in most animals and in some plants (e. g., *Mucorina*, *Siphonacem*). As a rule, the investment is most prominently developed upon the general outer surface of the organism.

By designating the constitution of the walls, it is intended to cover only the original or basic substance of which they are composed, and has no reference to subsequent depositions or infiltrations, of whatever character they may be. Thus in the walls of grasses and Equisetum there is often a great amount of silica, in certain seaweeds (*Corallina*) much lime, in tunicates so much cellulose that it sometimes amounts to one-fourth of the dry weight,\* and yet, in the case of the plants named, the original and fundamental substance of the wall is cellulose, and in the animals proteid. A small amount of nitrogen has recently been found by Winterstein† associated with the cellulose of fungi, but in what form has not yet been determined. Other instances of a similar nature might be cited.

It may be well to say that by cellulose is meant both primary and compound celluloses and their various modifications, all of which are carbohydrates, and by proteid is meant the nitrogenous, non-protoplasmic substance of walls, no formula for which is known, but which Cross and Bevan‡ suggest "may prove to be of similar carbon configuration to that of cellulose."

There are some organisms which, in their vegetative state, consist of so-called naked protoplasm, of which the most conspicuous and well known examples are the Myxogastres. Many species of these fungus animals (*Pilzthiere*), however, are known to possess a distinct proteid envelope about the plasmodium§ which, by its chemical reaction, is shown to be non-protoplasmic, and it may be inferred that careful examination will find it present in most of the species, and that it can be considered as potential or undeveloped in the others. They are, therefore, distinctly animal in their fundamental characteristic. Although usually treated in botanical text books and studied by botanists, they were long since shown by DeBary|| to have more points of agreement with animals than with plants, and he believed them to be "outside the limits of the vegetable kingdom." This separation by DeBary was made without any reference to a proteid membrane, which may, however, be considered the crucial diagnostic character.

Another set of organisms, with apparently naked protoplasm during the vegetative stage, are the endophytic parasites belonging to the group of genera represented by *Synchytrium*, *Woronina*, *Olpidiopsis*, *Rozella* and *Roesia*. Whether they ever possess any demonstrable proteid envelope has not been ascertained, but it is known that they have no cellulose envelope; they are, therefore, not plants, and must, in consequence, be animals. This disposition of them has already been made by Zopf\*\* on the ground that a "plasmodial character of the vegetative condition is entirely foreign to the Eumycetes." The Chytridiaceæ, which are usually associated with the Synchytriales, have a much reduced but demonstrable mycelium formed of cellulose, and are, therefore, unmistakable plants.

Among the lowest forms, as generally classified, the Rhizopoda, including *Amoeba*, and the far simpler *Monera*, show no distinct proteid envelope, but neither do they show any indication of a cellulose envelope, and as the other affinities appear to be with animals rather than with plants, they are doubtless rightly placed in the animal kingdom. It is reasonable to expect that more careful examination will, in some cases, show a simple or imperfectly formed proteid envelope.

It may be well to specifically state for sake of clearness that the nature of the investment of spores or sporophores has no significance in this connection. They are to be regarded as adaptations without primary classificatory value.

The crucial diagnostic character which is here proposed has in its favor the separation of plants and

\* Read before joint session of sections F and G of the A. A. S., Springfield meeting, September 2, 1895.—*Amer. Naturalist*.

† Duret, *Histoire admirable des plantes*, 1606; Jonston, *Dendrographia sive historia naturalis de arboribus*, 1682; La Croix, *Cousula florum*, ed. 2, 1791.

‡ Duret, l. c.; Gerarde, *Herball*, 1597.

§ Atlantic Monthly, 1860; Darwiniana, p. 124.

|| Philocephala botanica, ed. 4, 1869, p. 1.

\*\* Systematische Phylogenie der Protisten und Pflanzen, 1894; *Abh. in Science*, 1, 1895, p. 272.

†† Biology, 1890, p. 167.

‡‡ Ann. des sc. nat., 7th ser., Bot. T. V.; *Comp. Rend.*, 1887; *Le Botanical*, 1895, p. 188.

§§ Science, 1, 1895, p. 311.

\* Schmidt, *Zur vergleichenden Physiologie der wirbellosen Thiere*. Ann. d. Chem., 1845, p. 318; Schacht, *Müller's Archiv*, 1851, p. 185; Schafer, *Ueber Thiercellulose*, Ann. d. Chem., clx, 1871, p. 312.

† Ber. d. d. chem. Ges., xxviii (1895), p. 107.

‡ Cellulose, 1895, p. 88.

|| DeBary, *Morphology and biology of the fungi, mycetozoa and bacteria*, p. 400.

\*\* Die Mycetozoen, ed. 2, Leipzig, 1864; l. c., p. 444.

\*\*\* Die Pilze, 1890, p. 21.

animals upon a line which accords well with the consensus of opinion of thoughtful students, both botanists and zoologists, an opinion which has been formed from a variety of structural, physiological and developmental data. True relationship must necessarily be aduced from a study of the full life history of organisms, diagnostic characters only forming points of departure.

[FROM THE ILLUSTRATED LONDON NEWS.]

#### THE JACKSON-HARMSWORTH POLAR EXPEDITION.

FIFTEEN months ago the Polar yacht *Windward* steamed down the Thames on her way to the far North. Her destination was the frost-bound coast of Franz Josef Land; but between this region and the navigable waters of the Arctic Ocean there stretched a wide barrier of heavy ice. There were many to prophesy that she would not succeed in getting through this barrier, and the fact that last year was particularly a bad ice season helped the knowing to fortify their opinions with a timely argument. As time wore on and the winter of 1894 set in with no news of the *Windward*, even those Arctic experts who believed in her luck began to admit that she must have been frozen in, and had therefore become exposed to the new combination of perils which beset a ship in the Polar pack. Then the summer of 1895 came, and with it the daily

securv. It is, of course, perfectly arguable that of the thirty and three men who sailed away to this far-off region in the ice-bound North, the odd three might have found their death had they gone on a less perilous quest or even remained in the comparative security of a civilized country. But at the same time we may remember that they died in the very act of fulfilling a high and noble mission, and that to the long and glorious roll of those who have fallen in the search for the Unknown of the Arctic world the names of these three sailors may now be added.

Brighter, however, is the remembrance that all is well with the small and gallant band of explorers now left on Franz Josef Land, there to carry on the tale of adventure and the search for new lands and new seas, shut off from their fellow men by an all but impenetrable region of ice, and alone encouraged by the ultimate reward of discovery. It is to this small band of explorers that the world now turns its attention, and it is with their experiences up to last July that this brief narrative must deal.

To the letters which have been sent home by Frederick G. Jackson, the daring leader of the English Polar Expedition, we must look for information, and particularly to those letters which have been sent back to Mr. Alfred Harmsworth, the patriotic patron of the expedition. These letters have been placed in the hands of the present writer for this purpose, and it will be of the greatest interest to our readers if they

wood, as long as there is only enough of it. Thin planks of wood will not keep out either wind or cold, but the solid logs of which "Elmwood" has been built—each of them 12 inches square, with the intervening spaces soundly corked with moss—will resist and have resisted the lowest temperatures and the most furious gales.

This is what Mr. Jackson says of this admirable home: "Elmwood," our residence here, is situated on a raised beach, 115 ft. above the sea, forming a wind-swept plateau. The stable is directly east of it, and the four folding houses are in a line toward the same point. The latter proved quite useless as a residence, but came in as storehouses. The Russian loghouse we have fitted up capitally, and lined it with green felt, and it looks as snug as the inside of a gun case. We sleep on the floor, rolling our blankets up during the day. I have not the smallest hesitation in saying that it is the best and most comfortable house ever put up in these latitudes. It has blown incessantly, often with very low temperatures, all through the autumn and winter; so we have been glad of a good substantial house."

Throughout the winter preparations were going on for the march north to be begun in the spring. Mr. Jackson kept his men in constant active exercise, and every day something was done in the way of collecting specimens or bagging bear. Clothes and equipment were also tested in a variety of ways, and it was found



THE JACKSON-HARMSWORTH POLAR SETTLEMENT.

expectation of news. Yet month after month slipped away and no news came, until, at last, in the middle of September, the tidings were flashed along the cable from Vardo, a small port beyond the North Cape of Europe, that the *Windward* had come out of the dense ice pack, and that she had safely made once again an inhabited coast. Little wonder that the news had been so long in coming! For sixty-five days she had been battling with the ice—and battling with long odds against her. For long before she had burst her way through the three hundred miles of pack, her coal had run short, and to find fuel for her furnaces the topgallant masts and yards, the mizzenmast, the bulwarks from end to end of the ship, the bridge, the between-decks—in short, every available and dispensable spar and bulkhead had been broken up and converted into steam power. This was an absolutely necessary step, and a perfectly natural one to take; but there are many who, as they read of this strenuous endeavor, will feel their pulses quicken in sympathy with the fortunes of the voyagers who were thus compelled to break up, piece by piece, the good ship which alone, as it was, stood between them and death.

All's well that ends well, and happily the news the *Windward* brought was, with one exception, of the brightest and most satisfactory kind. The exception of course was in the death of the three brave fellows who laid down their lives in doing their duty, and succumbed to the ravages of the fell disease of

are given as much as possible in the very words of their gallant countryman.

"Here we are," he writes in the cheeriest way, with the thermometer scores of degrees below zero, and his position on the earth's surface indicated by so high a latitude as 80°—"here we are, safe and sound and as comfortable as bees, with a very familiar name to our residence of pine logs, called Elmwood, after the pretty place in Kent where I have enjoyed your and Mrs. Harmsworth's hospitality. We forced our way here, helped by a southwest gale, through a very tight barrier of ice. . . . On September 10 we began unloading our stores, and I set all hands to work—sixteen hours on and eight hours off—in the hope of getting our goods on shore and the ship away before the winter. But only three days after this winter 'whipped in' very suddenly."

Work for a while was very necessarily stopped, until the ship was secured in favorable winter quarters and the ice had become sufficiently strong to bear the weight of transporting the stores. Here the ponies and dogs came in very usefully, and before the end of October everything was landed, the houses and the store sheds erected, and the party comfortably settled in their new home.

Cobblers will tell you that there is nothing like leather, and carpenters may be expected to echo, "There's nothing like wood." At any rate for an Arctic dwelling there is absolutely nothing to equal

that the marching outfit could be lightened a good deal.

For example, Mr. Jackson was not satisfied with the deerskin sleeping bags, and describes in one of his letters the following test applied to his clothes: "On several occasions during the winter I slept out on the top of the flat roof of the house, having a clear sky above me and the thermometer down to 40° Fah. At other times a heavy gale was blowing with the temperature not above 35° Fah., which is cool; but yet I found that sovik, militza, pimmies, and tobacco (footwear), after making one or two alterations and contrivances of my own, lick the reindeer sleeping bags; and I tried the latter in many different forms."

It will be remembered that Mr. Jackson describes in his interesting book, "The Great Frozen Land," how he slept with warmth and comfort out on the open tundras in the depth of winter; and his experience then, with which he was well satisfied, has been confirmed by these tests in Franz Josef Land. There can be no question that the Samoyad form of clothing is admirably adapted for the Arctic winter, and enables the explorer materially to lighten his equipment, and, on occasion, to dispense even with his traveling tent.

At last the long, dark winter—not in the case of the latest expedition the season of idleness it frequently is—came to an end. On February 23 the rim of the sun curved red above the white horizon, and as each day went by, more and more of his orb rose above the

desolate world, bringing color to a colorless landscape, life to the waters and floods of the ice-bound coast, and opportunity for travel to the eager explorers.

On March 10 all was in readiness for a preliminary center toward the north. Loading up four sledges with 1700 pounds of stores and accompanied by Lieutenant Armitage and one of the ship's crew, Mr. Jackson started to form his first depot. "We had most unlucky weather," he writes, and indeed they had. The fog was so thick that they could not see their way for more than fifty yards ahead; and when the fog lifted the snow fell. On the fifth day, however, it cleared, and the first depot was satisfactorily established about forty miles north of the base, and marked by two Union Jacks. The party then returned for more stores, arriving safe and sound at Elmwood on the 16th.

On April 4 the ship was placed in great peril by a sudden break-up of the ice. For more than a week furious gales from the east had prevailed, but no one thought that the heavy ice would be greatly affected so early in the season. Suddenly, however, and literally without a minute's warning, great crevices were rent in the ice near the ship, with cracks and reports like thunder. A whale boat, which was lying alongside the ship on the port side, was swept away in a moment and a sheet of open water lay where only a few seconds previously there had been solid ice, ten to fifteen feet thick. So swift was the movement and so sudden the change of the Polar pack! Yet both movement and change are often intensely local, and this characteristic saved the *Windward* from being swept out of the safety of her winter quarters into the peril of the swirling pack. For while the ice on the port side had been swept clean away, that on the starboard side still adhered to the ship. She lay, as it were, in a half-mould of coarse crystal. But at any moment the ice might be rent asunder, and not a moment, therefore, was to be lost. The wind was blowing with the force of a gale, and snow was driving thick. Calling all hands together, both land party and crew, Mr. Jackson got long lines secured to the ship and paid out to a huge grounded berg which lay near by. There was a large floe of grounded ice to the starboard, and to this also he made the ship fast by means of lines. No fires were in the furnaces, and, of course, there was no possibility of getting up steam. The sails might have been set, but they were as stiff and hard as steel sheeting. Clearly, it was impossible to rely on the motive power of the ship, and therefore all efforts were concentrated on making her fast to the portions of ice less likely to break up. Yet, with commendable prudence, Mr. Jackson set the engineers and firemen at work, and took in a large quantity of ice as ballast (the ship being very light). Thus for a time things were safe; but a short while afterward a huge ice floe, many miles in length and having a sharp triangular bow, drifted rapidly down upon the ship. Had it touched her, she must have been swept away from her quarters and probably with a big hole in her side. But, by a most fortunate chance, the pointed floe just passed along her side and struck the land floe (between the ship and the coast) with a terrific crash, throwing up hummocks of ice of great size. Then turning, as ice so often does, upon its own axis, it swung around gently and inclosed the ship completely. The *Windward* was again safe in winter quarters, and it was not until July that any further change took place in the condition of the ice in which she lay.

The delay due to this threatened peril and other causes prevented the beginning of the second march northward until April 16. The party that then started consisted of E. G. Jackson, Lieutenant Armitage and Blomqvist, a Russian Finn, who had been shipped as an A. B. They had three ponies and six sledges, and were accompanied for the first week by R. Kettlitz, the doctor, and W. Heyward, storekeeper. Throughout the whole of this march the weather was very bad, but before May 13, when the journey was concluded, a distance of more than 300 miles was traversed and three depots erected, while two boats were safely housed in so high a latitude as 81 deg. 20 min.

The only expedition which had previously gone in from the south coast was the Austro-Hungarian expedition, led by Payer and Weyprecht, more than twenty years ago. It now seems from Mr. Jackson's discoveries that Payer's map (made during a very hurried march north) is so inaccurate that the English expedition did all this second journey on sea ice, but over a track marked as land in Payer's map! Not only was this the case, but lofty mountains indicated in Payer's had somehow or other totally disappeared. The character of those parts of Zichy Land which abut on Markham Sound was not in the least like that described in Payer's book. In a word, Jackson has carefully marched several times over a region never before traversed, and he has been able to rectify the information we had previously obtained of other parts of this corner of the Arctic world.

Throughout his march he bears testimony in his daily journal to the inestimable importance of horses in Arctic travel. Like every other form of aid, they have their drawbacks; but Mr. Jackson is emphatic in declaring that there is nothing to equal them as draught beasts, even over rough ice. But the ice must be in good condition—sound and firm—and it was the early break-up of the ice and its rapid deterioration into slush and water which alone compelled his premature return.

Yet this break-up had its advantages, for it enabled Jackson directly he had seen the ship off on her southern voyage, to go north in the specially fitted boat, the *Mary Harmsworth*. Of this, his third journey, we shall have no tidings until next year; but it is almost certain that he will be able to reach a high latitude by traveling up the lanes of open water which lie between the fringe of shore ice and the moving sea pack.

Meanwhile, I may quote a passage in which he describes the retreat, when the early break-up rendered it necessary to return to the base, before the ice road had melted under their feet and become open water:

"In this boggy slush the ponies are, of course, quite helpless. They simply lie and flounder, and we had to drag them out by hand with lines round their necks, and the sledges one by one, while we waded about in slush above our knees. This little experience was repeated a dozen times in the day. I used to go

ahead with a long-handled ice ax, sounding and trying to pick a road, but frequently there was no choice, and we had to drag the ponies and sledges through it as best we could. Fortunately, we were then able-bodied individuals, and in perfect health, or we should have looked very foolish. . . . On May 5 the black pony broke through the ice and nearly disappeared—fortunately he did not struggle until I had passed the reins round his neck or he would have gone altogether. Eventually the three of us managed to haul him out on to the ice. Often we had to drag the six sledges ourselves, having got the ponies through particularly bad places on ahead and going over the same ground twelve or fourteen times. Occasionally we would come to sound ice and go ahead briskly again, but it did not last long, and the old entertainment of hauling the ponies out of the bog and pulling up the sledges soon began again. I at last tried snow shoes for them, and made them of empty oat bags with a little hay in the bottom, and tied these round the ponies' feet. This helped to keep them up, while it gave them a most gouty and ludicrous appearance. But to cut the yarn short, we did bad luck in the eye, and got them back, dead beat, but all right, in the early morning of May 13, having traveled 310 miles."

There remains the story of the *Windward's* struggle with the great ice barrier on her way home; the story of the gallant efforts of the crew when weak with

The stems contain a large quantity of saccharine juice, which, when boiled, becomes a sort of treacle, and is much esteemed as an article of food, known as *Miel de Palma*—palm honey. A full-sized trunk yields about ninety gallons of this sap, to obtain which the trunks are felled, the leaves lopped off, and the juice is caught as it runs from the upper end.

There is some danger that this palm will soon be extirpated from Chile, through the wholesale felling of the trunks for the palm honey. When Darwin visited Chile in 1832, as recorded in his *Voyage of the Beagle*, it was very abundant in the country round Valparaiso, he having counted several hundred thousand trees on one estate alone. The late Mr. John Ball was there in 1883, and although he devotes a considerable portion of his book (*Notes of a Naturalist in South America*) to the flora of Chile, he does not even mention the *Jubæa*. Miss North visited Chile in 1884, and painted a picture of the *Jubæa*, which is in the Kew collection. "In a place called Salto, one of the most attractive coast suburbs of Valparaiso, there is a valley full of the native palm, *Jubæa spectabilis*, which used to cover the country forty years ago, but now scarcely a hundred trees remain. They are misshapen things, but seem quite in character with the rocky valley they grow in" (*Recollections of a Happy Life*).

According to Siemann, the *Jubæa* is cultivated in Colombia and other parts of South America. The



JUBÆA SPECTABILIS IN THE KING OF PORTUGAL'S GARDEN, LISBON.

disease or overcome with fatigue; the story of her final escape from the ice pack and of her safe making of the Norwegian port of Vardo. But this is now familiar to the public, and need not be repeated here.

And there is this final thought. Of the few, the very few, Arctic expeditions which have started with a definite programme for the first year's work and succeeded in carrying it out, there has been not one expedition which has achieved its objects with such completeness, or with so small a loss, as the Jackson-Harmsworth expedition, and we, as Englishmen, are rightly proud to watch it bearing aloft in the Arctic world the wreath of undying laurel which was long since gained by the courage, the devotion, and the self-sacrifice of a long line of our gallant countrymen.

A. M.

#### JUBÆA SPECTABILIS.

THE Coquito Nut or Wine Palm of Chile is one of the most interesting of sub-tropical palms. It has a very stout stem which attains a height of from 40 to 60 feet, and bears a large spreading head of pinnate leaves. The fruit is borne in pendent racemes which look like gigantic bunches of very large grapes. Each fruit contains a single seed which is nearly round, has a hard brown bony shell, and the albumen is white, harder than in the coconut and sweet to the taste.

seeds are sometimes imported to this country, and are known commonly as monkeys' coconuts. They are eaten by boys, but I know of no other use to which they are put in this country.

There is a large healthy specimen of this palm in the temperate house at Kew. It has a trunk 8½ feet in circumference at the base, and 7 feet at a distance of 5 feet from the ground. It bears a grand head of feathery like leaves, each 17 feet long and 4½ feet wide, and certainly is not a misshapen thing, as described by Miss North. The accompanying figure represents a specimen of the *Jubæa* in the King of Portugal's garden at Lisbon, which was published in the *Gardeners' Chronicle* in 1882 [and which we now reproduce]. At that time the trunk was 13½ feet in circumference. In 1886, this identical specimen flowered and ripened fruits. It was then thirty-five years old, and had a trunk over 16 feet high and 14 feet in circumference at the base. The flowers were produced in January, and the fruits ripened the following August. I believe this is the only recorded instance of this palm flowering and fruiting in Europe.

I have seen it thriving in the open air in gardens on the Riviera, a specimen in Mon. Naudin's garden at Antibes having a trunk nearly as large as that at Kew, but the leaves were much shorter and less handsome. [This tree, as M. Naudin kindly informed us, when he sent the fruit figured, is 16 feet high, the girth of the

trunk at a yard high is more than 12 feet, and the age of the tree is 36 years. Ed. I believe there is a plant out of doors in the garden of Mr. Smith-Barry at Fota, near Cork, which requires only slight protection in winter. A plant was tried in the Bamboo Garden at Kew two years ago, but it succumbed to the first severe frost. W. W. Kew.—The Gardeners' Chronicle.

(FROM NATURE.)

## LATENT VITALITY IN SEEDS.

THERE is no doubt, as M. Casimir de Candolle has recently shown in his paper on latent life in seeds, that all the functions of seeds can remain completely quiescent for a long period; probably in some cases this period may be indefinitely long. In 1878 I published a paper\* on the resistance of seeds, especially of *Medicago sativa*, or lucerne, to the action of gaseous and liquid chemical reagents. An abstract of my experiments was published in *Nature*, vol. xiv, 1882, p. 338.

Recently I have examined portions of the seeds used in the experiments of 1877 and 1878, to see if after the lapse of so many years, during which the seeds have remained constantly surrounded by special gases, or immersed in different solutions, they had retained their vitality. The results have been remarkable, for in some cases a large proportion of the seeds have maintained their vitality after a lapse of 15, 16, and nearly 17 years of special external chemical conditions. I summarize the results of some of my experiments.

## (a) EXPERIMENTS IN GASES.

In all these experiments the gases were dry, for in these conditions moisture is rapidly fatal to the seeds. The seeds were introduced into small bulbous tubes, into which the dry gas was made to pass for some time, after which the tubes were rapidly sealed at a spirit-lamp flame. The tubes were then kept in the dark.

In the following summary I give the dates of the sealing and opening of the tubes:

**Hydrogen.**—Lucerne seeds, from September 15, 1877, to August 5, 1894, a period of 16 years, 10 months, and 20 days. Out of 51 seeds sown, none germinated. Seeds of wheat, vetch, *Cynara cardunculus* and coriander, kept in hydrogen, gave the same negative results. There is some suspicion that the hydrogen had not been originally well dried.

**Oxygen.**—Lucerne, from May 19, 1878, to August 4, 1894, 16 years, 3 months, and 15 days. Out of 293 seeds sown, 2 germinated, or 0.68 per cent. The seeds were not thoroughly dry.

**Nitrogen.**—Lucerne, from April 12, 1878, to August 31, 1894, 16 years, 3 months, and 22 days. Out of 330 seeds, 181 germinated, or 54.56 per cent.

**Chlorine and Hydrochloric Acid Gas.**—Lucerne, from April 28, 1878, to August 3, 1894, 16 years, 3 months, and 5 days. Out of 342 seeds, 23 germinated, or 6.72 per cent. Originally these seeds had been put into pure chlorine; but the gas had acted on the seeds, carbonizing a portion of them, so that at the end of the experiment the seeds were in an atmosphere composed chiefly of hydrochloric acid gas, mixed with carbon dioxide.

In a second experiment with lucerne seed, kept in chlorine, and then hydrochloric acid, during the same period, out of 167 sown, 10 germinated, or 5.98 per cent. In this experiment the tube was carefully opened in vacuo, to protect the seeds from the moisture condensed by the hydrochloric acid gas at the moment when it is brought into contact with common air.

**Sulphureted Hydrogen.**—From October 14, 1877, to August 5, 1894, 16 years, 9 months, and 23 days. After the opening of the tube, filled with the strongly smelling gas, the seeds were left in contact with the air for 24 hours before sowing them in the moist sand of the germinator. Out of 101 lucerne seeds, one germinated, or 0.99 per cent. Out of 50 seeds of wheat, none germinated.

**Arsenureted Hydrogen.**—From April 4, 1878, to August 4, 1894, 16 years, 4 months, and 4 months. On opening the tube the garlic smell of  $AsH_3$  was strongly evident. Out of 255 lucerne seeds sown, 181 germinated, or 70.98 per cent. In a second experiment with seeds kept in arsenureted hydrogen, out of 247 lucerne seeds 170 germinated, or 68.82 per cent.

**Carbon Monoxide.**—From April 3, 1878, to August 4, 1894, or 16 years, 4 months. Out of 266 lucerne seeds, 224 germinated, or 84.2 per cent.

**Carbon Dioxide.**—From September 8, 1877, to August 5, 1894, or 16 years, 11 months, and 27 days. The same tube contained seeds of lucerne, wheat, vetch, *Cynara*, and coriander. None germinated. Perhaps the large number of seeds contained in a relatively small tube rendered the carbon dioxide damp, and therefore noxious.

**Nitric Oxide.**—From May 2, 1878, to August 4, 1894, or 16 years, 3 months, and 2 days. On opening the tube, abundant red fumes were produced by contact with air. Before sowing, the seeds were left dry for 24 hours. Some of the seeds were brownish, the rest retained their natural color. Out of 300 lucerne seeds, 3 germinated, or 0.97 per cent. In a second experiment, the tube containing the lucerne seeds was opened in vacuo; out of 330 seeds, 2 germinated, or 0.62 per cent.

## (b) EXPERIMENTS WITH LIQUIDS AND SOLUTIONS.

I give only the results obtained with alcohol and alcoholic solutions. In other liquids, such as ether and amyl alcohol, the liquids had gradually evaporated, so that the exact period of their action could not be ascertained, and the seeds, covered with a moist, oily varnish, had lost all vitality. Lucerne seeds kept in chloroform for 16 years and 4 months were completely lifeless. In all the recorded experiments the seeds were completely immersed in a relatively large volume of liquid.

**Strong Alcohol.**—From March 26, 1878, to August 6, 1894, or 16 years, 4 months, and 13 days. The alcohol was originally absolute, but in contact with the seeds, and during so many years must have absorbed a small proportion of water. Before being sown, the lucerne seeds were carefully air-dried on a filter for 12 hours. Out of 60 seeds sown, 40 germinated, or 66.6 per cent.

\* Italo Giglioli. "Resistenza di alcuni semi all'azione prolungata di agenti chimici, gascosi e liquidi." *Gazzetta Chimica Italiana*, ix, 1879, p. 199; and *Giorn. delle sc. nat. sper. ital.* viii, 1879, p. 190.

**Concentrated Alcoholic Solution of Corrosive Sublimate.**—The alcoholic solution was originally prepared with alcohol nearly absolute, and saturated with mercuric chloride. From May 23, 1878, to August 17, 1894, or 16 years, 3 months, and 25 days. On taking the seeds from the mercuric solution, they were very carefully washed with alcohol at 97 per cent, until every trace of the mercuric compound was washed away. The seeds were dried at the ordinary temperature, and then sown. Out of 79 lucerne seeds, 16 germinated, or 20.3 per cent.

**Alcoholic Solution of Sulphur Dioxide.**—From November 10, 1878, to August 24, 1894, or 15 years, 9 months, and 14 days. Originally the alcohol was of 93 per cent. strength; the solution preserved a suffocating odor of sulphurous acid. The lucerne seeds were mixed with minute sulphur crystals; the seeds were well washed with strong alcohol, dried and sown. Out of 645 lucerne seeds, one alone germinated, or 0.15 per cent.

**Alcoholic Solution of Sulphureted Hydrogen.**—From November 10, 1878, to September 4, 1894, or 15 years, 9 months, and 15 days. The alcohol, originally 93 per cent. strength, had been repeatedly saturated with sulphureted hydrogen gas. The liquid emitted a marked mercaptanic smell. Sulphur crystals were formed, and sedimented with the lucerne seeds. The latter were washed with 97 per cent. alcohol, and then air dried. Out of 583 seeds, 41 germinated, or 7.03 per cent.

**Alcoholic Solution of Nitric Oxide.**—From November 10, 1878, to September 4, 1894, a period equal to that of the last described experiment. The alcohol, 93 per cent. strength, had been repeatedly saturated with  $NO$ . Before sowing, the seeds were washed with alcohol and dried. Out of 388 seeds, 12 germinated, or 3.10 per cent.

**Alcoholic Solution of Phenol.**—The lucerne seeds preserved in the solution for over 15 years showed no signs of vitality. In washing the seeds, previous to sowing, with alcohol, they could not be completely purified from the phenol.

Many of the germinating lucerne plants developed from the seeds used in these experiments were transplanted from the germinator into flower pots. The plants grew well, and have flowered and seeded normally.

At the beginning of these experiments, in 1877 and 1878, I was not aware of the noxious action of even small proportions of moisture. It is probable that if in all these experiments special care had been taken at the beginning to exclude as much as possible moisture both from the seeds and from the gases or liquids, a much larger proportion of seeds would have retained their vitality. The difficulty of preserving the vitality of large seeds must be chiefly caused, in all probability, by the difficulty of thoroughly drying them.

These experiments are of interest in showing that seeds may retain their vitality in conditions when all respiratory exchange is completely prevented for a long series of years. They fully confirm the results of the late G. J. Romanes, who proved that seeds may preserve their vitality for 15 months when kept in vacuo, or when transferred from the vacuum tubes to other tubes, charged with sundry gases or vapors.\*

My experiments encourage, moreover, the suspicion that latent vitality may last indefinitely when sufficient care is taken to prevent all exchange with the surrounding medium. There is no reason for denying the possibility of the retention of vitality in seeds preserved during many centuries, such as the mummy wheat, and seeds from Pompeii and Herculaneum, provided that these seeds have been preserved from the beginning in conditions unfavorable to chemical change. The original dryness of the seeds, and their preservation from soil moisture or moist air, must be the very first conditions for a latent secular vitality.

In experimenting with seeds from Pompeii and Herculaneum, I have not as yet been able to find among them any living grain. The greater part of these seeds are too much carbonized and changed to permit the entertaining of much hope as to their possible vitality. Especially among the seeds of Pompeii, the carbonization must have been caused by the slow action of moisture, which would speedily destroy all life in the seeds. Among the Pompeian wheat the destruction of organic matter has been so great as to leave in the seed, in its present condition, a proportion of ash as high, in some cases, as 4.2 per cent., and even 8.4 per cent.

On the other hand, some of these seeds, as those found in the granaries of the Casa dell' Arzo, at Herculaneum, in 1828, seem to have been in conditions favorable to a prolonged preservation of latent vitality; the millet seeds, especially, were found unchanged in outer aspect. Unfortunately, no test was made at the time of their discovery, and since then the action of moist air, and exposure to changes of temperature and to light, must have impaired fatally any remnant of vitality still lurking among the seeds.

All researches on latent life are of great interest in ascertaining the nature of living matter. The present researches have established that, for some seeds at least, respiration, or exchange with the surrounding medium, is not necessary for the preservation of germ life. It is a common notion that life, or capacity for life, is always connected with continuous chemical and physical change. The very existence of living matter is supposed to imply change. There is now reason for believing that living matter may exist, in a completely passive state, without any chemical change whatever, and may, therefore, maintain its special properties for an indefinite time, as is the case with mineral and all lifeless matter. Chemical change in living matter means active life, the wear and tear of which necessarily leads to death. Latent life, when completely passive, in a chemical sense, ought to be life without death.

It may be finally remarked that the proof of the resistance of seeds to vacuum, of the non-necessity of a respiratory exchange with outer air, together with the proof of the resistance in some seeds to very low temperatures, are facts encouraging the belief that the origin of life on our globe may be due to the introduction of germs that have traveled, embedded in aerolites, from other planets where life is older than upon the earth.

ITALO GIGLIOLI.

\* *Nature*, December 7, 1893, p. 140.

## COMMERCIAL FIBERS.\*

By D. MORRIS, C.M.G., M.A., D.Sc., F.L.S., Assistant Director of the Royal Gardens, Kew.

## LECTURE I.

THE commerce in fibers is admittedly of great importance. It is one of the largest in the United Kingdom. The total imports of raw fibrous material during the year 1893 were of the value of £56,000,000 sterling. The total exports—chiefly manufactured goods—were of the value of £74,000,000 sterling. Hence the total turnover in fibrous substances in 1893 was of the estimated value of £134,000,000 sterling. Of this large amount, India and the Colonies contributed about 10 per cent. of the imports. The table given below will indicate the sources whence the fibrous materials received in the United Kingdom were derived:

VALUE OF IMPORTS DURING THE YEAR 1893.

	Foreign Countries.	British Possessions.
	£	£
Cordage material.....	502,145	185,475
Cotton, raw, yarn, etc.....	34,618,079	1,202,790
Flax, raw, etc.....	1,103,377	1,474
Hemp, etc.....	2,213,735	238,022
Jute.....	3,721,973	3,640,185
Paper material:		
Esparto, wood pulp, etc....	2,054,696	*40,170
Linen and cotton rags.....	199,155	4,859
Pulp of rags, etc.....	231,119	44,990
Total.....	£44,644,279	£5,357,965

\* Wood pulp from Canada.

## SUMMARY.

Foreign countries.....	£44,644,279
British possessions.....	5,357,965
	£50,002,244

The small proportion of fibrous substances received from British possessions is very striking. This was not due to the fact that fibers were unsuited to the circumstances of Colonial and Indian industries. India itself grows immense quantities of cotton, but 42 per cent. of it is shipped to foreign countries. There is no doubt room for considerable expansion in the cultivation of fibers in British possessions. For instance, the Dominion of Canada is capable of growing excellent flax, specimens of which were shown at the Colonial and Indian Exhibition of 1886. Natal possesses a local variety of hemp (*Cannabis*) of singular merit for textile purposes. Queensland can produce a *Sida* fiber better than Indian jute. Victoria, in the northwest portions of its territory, has promising lands for flax growing that would support an industry far more profitable than wheat growing; while New Zealand has only to make its *Phormium* fiber available for the higher textiles to establish an industry of the greatest value. The plant is abundant everywhere in a wild state, and it is a most persistent member of the local flora. Its systematic cultivation is, therefore, hardly necessary for some time to come. The Maori cleaned fiber is better selected and better prepared than the machine fiber, and this indicates the direction in which improvement should take place.

The West Indies are finding it difficult to grow sugar to compete successfully with beet sugar, and if a change of culture were imperatively demanded, some of the islands could grow the best sorts of sea island cotton, and so go back to the position of a hundred years ago, when the West Indies supplied nearly all the cotton required for the world's markets. It is also open to them to grow ramie, pre-eminent among vegetable fibers for strength, fineness and luster.

In the Bahamas a large effort is being made to grow *Sisal* hemp, a valuable white rope fiber extensively used both in this country and in the United States. Mauritius hemp has been produced for many years, and the industry has been well sustained in spite of periodical depression in prices. West Africa has lately produced from the vine palm a bass fiber of considerable value. This is obtained also in Ceylon and India from the *Palmyra* palm. In all these possessions the prospects of development are encouraging, provided, however, the industries are not over-loaded with capital, and the cost of production is reduced within the lowest possible limits.

Commercial fibers have hitherto been regarded as a heterogeneous group of natural phenomena. They have been studied piecemeal, rather than in a systematic manner, based upon the morphological or chemical character of their constituent elements. Botanically, they might be dealt with according to the sequence of the natural orders of the plants yielding them. Such a plan should not, however, be strictly followed, as we would have to deal at one time with different sorts of fibers—say bast fibers and seed hairs—yielded by one and the same plant. While, therefore, the botanical arrangement will, in the main, be followed, it will be necessary to depart from it whenever certain morphological and structural distinctions arise requiring special treatment.

Vegetable fibers have received considerable attention of late years. Numerous writers have described their origin and characteristics, and a large mass of information has been accumulated respecting them. The fibers of our Indian Empire have been specially studied. Two early investigators in the field of fiber research are deserving of special mention. Dr. Hugo Müller, in "Die Pflanzenfaser" (Brunswick, 1876), a work that first appeared as a report on the vegetable fibers at the Vienna Exhibition of 1873, may be said to have started the chemical method of examining commercial fibers and laid the foundation of much of what has been done since that time. The late M. Vétillard ("Etudes sur les fibres végétales textiles," Paris, 1876) investigated the microscopic structure of commercial fibers, and drew careful and accurate de-

\* Lectures before the Society of Arts, London, March, 1895.—From the Journal of the Society.

ductions between the structure of the fibers and their value in commerce.

Since 1876, the field of investigation, from the chemical side, has been successfully occupied by Messrs. Cross and Bevan. The former prepared the official report for the Royal Commission on the miscellaneous fibers shown at the Colonial and Indian Exhibition, 1884, and was further associated with Dr. George Watt, in the preparation of a "Report on Indian Fibers and Fibrous Substances," published separately (London: Spon, 1887). Quite recently Messrs. Cross and Bevan have published a valuable textbook on "Cellulose" (London: Longmans, 1895), giving an outline of the chemistry of the structural element of plants, with reference to their natural history and industrial uses. The botany of vegetable fibers, especially in regard to those that have come into prominent notice of late years, has been very fully treated in various articles in the "Kew Bulletin" (London: Eyre & Spottiswoode, 1887-1895). Detailed information respecting the fibrous plants of India may be obtained from Watt's "Dictionary of the Economic Products of India," vols. i-vi (London: Allen & Company); while general information may be gathered from Spon's "Encyclopedia of the Industrial Arts," 1881, in a series of articles on "Fibrous Substances." At the close of these articles there is a very extensive bibliography of works dealing with vegetable fibers.

In works treating of the economic properties of tropical and sub-tropical plants nothing is more common than the references frequently made to the fiber-yielding properties of these plants. There are, no doubt, thousands of plants capable of yielding fibers of some sort. For instance, we are informed that there are over 300 fiber-yielding plants found in our Indian Empire. Of these, at least one hundred are said to afford strong and useful fibers, which are regularly used by the natives of India. Only thirty are, however, worthy of European recognition, while those actually utilized for commercial purposes do not exceed ten.

The total number of fibers employed in European manufacture is singularly small. In fact, it is little more than it was fifty years ago. Some new fibers have no doubt been introduced, but they are in many cases of lower textile value, and have been chiefly used as adulterants of the more expensive and higher fibers. A great change has, however, taken place in the quantity actually produced of all fibers, and, as already shown, the commerce in fibers is now of great importance. The principal vegetable fibers in order of commercial value are—cotton, jute, flax, hemp of different sorts, paper material (esparto and wood pulp), cordage material, coir and brush material, and raffia. This is a singularly small list.

It has been asked whether the general neglect of many really valuable fibers known to exist in many parts of the world arises from some defect in the cultivation, in the want of suitable appliances to extract the fiber, or in the incidents of distribution and commerce. It is difficult to understand why some undoubtedly valuable fibers have hitherto been quite neglected. The fibers themselves have been carefully and exhaustively examined, and they have proved of great merit. In spite of this, however, they are still unknown in commerce, and such an intrinsically inferior fiber as jute occupies a position second only to cotton and flax.

It will be the object of these lectures to bring into prominence several fibers quite as deserving of notice as those already in use. They will be found to possess qualities in some degree superior to those now in commerce, while their special adaptation for cultivation on a large scale in British possessions in the tropics should bespeak for them the attention they deserve.

Those anxious to study the plants yielding commercial fibers cannot do better than visit the large collections—possibly the most complete existing anywhere—at the Royal Gardens, Kew. Specimens of nearly all the plants mentioned in these lectures are to be found there, in a living state duly labeled. In the Museums of Economic Botany I and II may be seen the fibers themselves, in different stages of preparation, as well as the manufactured articles prepared from them. The guide books to the museums (obtainable at the entrance gates) indicate exactly the portions of each museum where the specimens are to be found. Students and men of business can thus make their own observations in this country almost as well as if they visited the tropics.

#### ESSENTIAL ELEMENT IN FIBERS.

In spite of the complexity and variety of the fibers known in commerce, and the different forms presented by the plants yielding them, the essential element on which their value depends is always the same. A fiber, to be of value, must consist of a substance known chemically as cellulose. The larger the percentage of cellulose, and the purer the quality, the better, in a general sense, is the fiber.

Cellulose has been described as the substance which constitutes the essential part of the framework of plants. In the young cells of plants the wall is formed of a delicate, but firm and elastic membrane. This wall consists of cellulose, which is, chemically, very similar to starch. The strength and elasticity of all parts of plants are ultimately due to the cell walls, which serve as a firm supporting framework for the whole structure. During the process of growth in plants, many cells become incrustated with coloring matter, resins and other substances, which, in some parts, as in the heart wood of trees, fill up the entire cavities. Some tissues, however, remain with little or no incrustation, and, although their walls are thickened, they consist almost wholly of cellulose. We have good examples of such cells in the perisperm of certain seeds, such as those of the ivory palm and the date palm, and in the pith of the rice paper plant (*Aralia papyrifera*) and the shola or pith helmet plant (*Eschynomene aspera*). The fine floss of cotton, kapok, and the seed hairs known as vegetable silks, are almost pure cellulose, as also such manufactured vegetable fabrics as linen, hemp, and unsized white paper. Cellulose, in its more compact form, is not colored by solution of iodine, but if previously disintegrated by sulphuric acid or caustic alkali, it produces a violet-blue color with iodine. This serves as a convenient test for cellulose in all microscopic preparations.

Cellulose, perfectly purified, is white, translucent, and of the specific gravity of about 1.5. It is insoluble in water, alcohol and oils, both fixed and volatile. Well bleached linen is composed entirely of cellulose, hence its value for paper making. Under ordinary conditions of the atmosphere cellulose is practically indestructible. For instance, in the Kew Museum, pieces of linen rags are shown taken from between undisturbed bricks in the temple of Hawara, built in B. C. 2500. They are thus over 4,000 years old. Cellulose is disintegrated by means of acids; hence vegetable fibers can be distinguished from those of animal origin, such as wool or silk. From a wool-cotton fabric the cotton is easily separated by soaking the fabric in dilute sulphuric acid. The disintegrated cellulose is removed, leaving the wool unaffected. The actual amount of cotton in a wool-cotton fabric can be thus estimated. The capability of cellulose of being gelatinized in cupro-ammonium solutions, and rendered of industrial use in "Willesden" and other goods, will be discussed later.

#### FIBER BUNDLES AND FIBER CELLS.

Although cellulose is found in all parts of plants, the parts that are of special value for yielding commercial fibers are certain cells which occupy a definite area in each plant, varying, however, greatly in the extent and form of distribution, as well as in the length, thickness of cell wall, and the nature of the adjacent tissues.

Fibrous cells are usually long, thick walled cells, with sharply, or sometimes bluntly, pointed ends. The wall is generally thickened all over, but there may be a few small, narrow pits, where the wall is left thin. The fibrous cells, unlike the vessels (through which the nutrient fluid passes to build up the plant), keep their living contents, and do not fuse with one another. They are, in fact, long narrow tubes, tapering at both ends, holding a fluid sealed up in the central cavity. The chief function of the fibrous cells in plants is a mechanical one; they serve merely to give rigidity to the plant, and prevent it from collapsing.

Fibrous cells overlap one another, and form, in the mass, a tissue, called prosenchyma. Numerous instances, showing the position and arrangement of fibrous cells, will present themselves later.

In the great division of plants known as Dicotyledons (having four or five parts to the flower, and

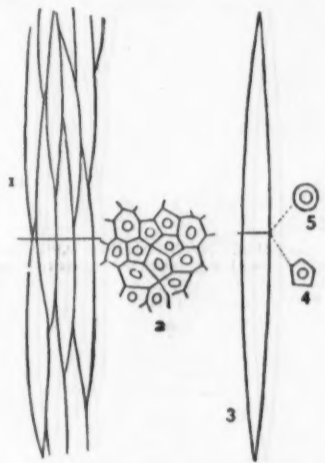


FIG. 1.—DIAGRAMMATIC REPRESENTATION OF A FIBER BUNDLE.

1. Longitudinal aspect showing the arrangement of the cells. 2. Transverse section exhibiting the relative position of the individual cells, the thickness of the cell wall, and the cavity. 3. An isolated fiber cell, much enlarged. 4. Section of a cell showing the polygonal form due to compression. 5. The normal form.

the veins of the leaves forming a network), the fibrous cells are to be found in the middle layers of the bark. In such parts are to be found the fibrous or bast cells of flax, hemp, jute, China grass, and paper mulberry.

In Monocotyledons (with parts of the flower usually three or six, and the leaves with parallel veins), the fibrous or bast cells are found built up with vessels into a composite structure known as a fibro-vascular bundle. These bundles are irregularly distributed in fleshy leaves or in stems, and are not localized into a continuous tissue as in the Dicotyledons. The fiber yielding plants among Monocotyledons are grasses, agaves, and other amaryllids, musas and palms.

In extracting fiber from plants by any process that will break up the tissue in which they are built up, the first aggregate that presents itself is a fiber bundle. This is composed of a number of cells adhering together and forming the unit from which the spinning thread is formed. In a cross section a fiber bundle shows a number of cells with walls more or less thickened, and a central cavity. Owing to the pressure to which the cells have been exposed, the walls are usually hexagonal, not round. If a fiber bundle is treated with alkalis, it will be resolved into its component units, and we have the ultimate fiber cell. In cotton and other seed hairs the ultimate cell is already isolated as an elongated tubular cell attached to the seed. In bast tissues, as has been shown, the ultimate cell is obtained only by a thorough disintegration by means of alkalis.

As regards the fiber bundles (being the spinning units), it is of great importance that they should be uniform as regards length and diameter. Further, they should have tenacity, flexibility, and smoothness, so as to give them good spinning qualities. The fiber cells, on the contrary, are to be examined first for length, then for thickness of wall, size of cavity, tapering ends, and, lastly, for uniformity in size and composition. Perhaps the most important factor of all is the length of the ultimate fiber cell, for although it is not the spinning unit, it is in a very direct sense the essential factor of strength and durability of the manu-

factured goods. In the subsequent process of bleaching the fiber bundles are disintegrated and the individual cells isolated. As a striking instance of the value of length in the fiber cell, we may compare the fiber cells of jute and flax. In jute they are only 3 mm. long, in flax they are 40 mm. long. In the case of jute, according to Messrs. Cross and Bevan, bleaching means "rotting"—that is, the whole fabric falls to pieces.

#### INVESTIGATION OF RAW FIBROUS MATERIALS.

The first step necessary in the investigation of plants for fiber purposes is to determine the position of the fiber bundles and their relative abundance in regard to other tissues. In the case of Monocotyledons, sections would have to be taken across the leaves, petioles, or stems. In Dicotyledons the stems alone are likely to yield fiber, and these only in the peripheral layers of the cortex encircling the woody parts. The further examination requires some care.

Very valuable hints respecting the histological examination of fibers are given by M. Vétillard in the work already cited. An abstract of his methods, revised by the author himself, is published in Christy's "New Commercial Plants," No. VI (1882). These are methods for the microscopical and structural investigation of fibers. Although useful in determining the relative abundance of the fiber bundles and the length and character of the fiber cells, they are by no means sufficient to afford a complete idea of the value of the fiber. To do this it is necessary to adopt chemical tests and carry them out with the precision which necessarily attaches to scientific measurements. Messrs. Cross and Bevan have remarked that "systematic inquiry, based upon uniform method, must contribute more than anything to the scientific development of a subject." We cannot do better than recommend for general use the more elaborate method found so successful by these original investigators. The Cross and Bevan method of chemically investigating vegetable fibers is fully explained in "Cellulose," part iii, pp. 242-310. It is admitted that a microscopical examination is necessary also. A review of the structure and anatomy of exogenous and endogenous plants must therefore precede, or at least accompany, the chemical investigation.

(To be continued.)

[FROM NATURE.]

#### THE STAR SHOWERS OF NOVEMBER.

WELL may Mr. Greg, in his catalogue of meteoric radiants, published in 1876, affix a remark indicating the all surpassing character of the mid-November meteors. For if there is one star shower more striking than all the rest, it is assuredly the Leonids. Every one who has seen the phenomenon at its best is prepared to admit that it furnishes a grander spectacle than any other system, and will have realized that, once seen, it impresses itself indelibly upon the memory. There can be very few people living now who witnessed the great shower in America on the morning of November 14, 1833, but there are many Englishmen who vividly remember the fine but less splendid exhibition of 1866. With a swiftness unapproached among meteor streams, and with a brilliancy quite their own, the Leonids belong to the most striking class of these bodies, and offer a great distinction to the slow and gentle flights of the Andromedes, or meteors of Biela's comet, which present themselves about a fortnight later.

It is true the Leonids are only manifested, in vast abundance, once in a generation, and that, considered as an annual display, they usually fall below the strength of the August Perseids. But, considering all things, the November shower is undoubtedly entitled to precedence. The writer saw the Leonids in 1866; he also observed the rich displays of Andromedes in 1872 and 1885, and has been fortunate enough to witness many bright returns of the Perseids and of other prominent systems; but, of all such spectacles, one only, by its surpassing splendor, created an impression which still lives fresh in the memory, and that was the Leonids of November, 1866.

The similar display which occurred in 1833 may be regarded as a very auspicious event, since it attracted attention to an important branch of astronomy which had been systematically neglected. Men began to seriously regard a phenomenon capable of giving such a remarkable sky picture, and the facts relating to it were collected and discussed. But the meteor showers of 1833 and 1799 were understood to be very exceptional events, and they had not been observed with that attentive regard to details which is so essential in this class of observations.

Astronomers, however, were led to suppose that historical records might contain references to similar phenomena witnessed in ancient times, and Herrick, Quetelet, Arago and others, on consulting old works, found a number of descriptions of star showers preceding that of 1799, and obviously of the same character. These occurred in 902, 931, 934, 1002, 1101, 1202, 1306, 1333, 1602 and 1608. A list of the dates was given by Prof. Newton in the American Journal of Science for May, 1864, and he found, on comparing the intervals separating the various returns, that these brilliant meteoric apparitions visited us four times in every 133 years. The descriptions of them were quaint and imperfect, and of little scientific value apart from affording an important clue as to the period of the swarm; but it may be interesting to quote from a few of them. In October, 902, a vast concourse of falling stars were scattered over the sky as thick as rain. On October 19, 1302, "stars shot hither and thither in the heavens eastward and westward, and flew against one another like a swarm of locusts; this phenomenon lasted until daybreak; people were thrown into consternation and cried to God the Most High with confused clamor."

A Portuguese chronicle thus refers to the shower of 1366: "Twenty-two days of the month of October being past, three months before the death of the king, Don Pedro, of Portugal, there was in the heavens a movement of the stars such as men never before saw or heard of. At midnight, and for some time after, all the stars moved from the east to the west, and after being collected together they began to move, some in one direction and others in another. And afterward they fell from the sky in such numbers and so thickly

together that, as they descended low in the air, they seemed large and fiery, and the sky and air seemed to be in flames, and even the earth appeared as if ready to take fire." Coming down to modern displays, Humboldt saw thousands of bolides and falling stars succeed each other during four hours on the morning of November 13, 1790. The phenomenon returned in 1831 and following years, and the facts may be referred to seriatim:

1831, November 13, A. M. An account of this shower was given to M. Arago by one of the officers of the French brig Loiret as follows: "The sky being perfectly cloudless and a copious dew falling, we have seen a number of shooting stars and luminous meteors of great dimensions. During upward of three hours two per minute were seen. One of these meteors which appeared in the zenith left an immense train from east to west, like a luminous band, and the light it gave did not disappear for six minutes."

1832, November 13, A. M. Capt. Hammond, of the ship Restitution, then in the Red Sea, off Mocha, says: "From 1 A. M. until daylight there was a very unusual phenomenon in the heavens. It appeared like meteors bursting in every direction. On landing in the morning I inquired of the Arabs if they had noticed the above. They said they had been observing it most of the night, but had never seen the like before."

1833, November 13, A. M. The phenomenon continued during seven hours. At Boston the number of meteors was considered to equal one-half of the flakes which filled the air in an ordinary fall of snow. The number visible was estimated as upward of 240,000. Another observer stated that between 4 and 6 A. M. about 1,000 meteors per minute might have been counted.

1834, November 13, A. M. A large number of shooting stars seen in the United States.

1835 and 1836. Many meteors observed on same date. In the latter year, on November 13, A. M., an immense number of meteors made their appearance between midnight and daylight, but the display did not equal the shower of 1833.

1864, November 13, A. M. An observer on board the steamship Ellora, off Malta, wrote on November 14 as follows: "There was a grand display of meteors from midnight to 4 A. M., all through the watch, the night before last. The watch, an old 'salt' and an intelligent man, said that it was the grandest shower he had ever seen." None were visible on the morning of November 14.

1865, November 13, A. M. Between 1 and 5 A. M., 279 meteors were seen by six observers at Greenwich, and it was computed that the total number visible during that period must have been fully 1,000. Prof. Herschel noted 71 meteors between midnight and 3 A. M. At Cambridge University 98 meteors were observed between midnight and 3 A. M.

1866, November 14, A. M. 8,485 meteors were counted by several observers at Greenwich. Mr. Wood, at Birmingham, estimated that between 1 and 1:30 A. M., meteors appeared at the rate of 3,000 per hour. The maximum occurred at about 1:10 A. M., when Dr. Burder, of Bristol, counted 60 per minute. From the combined observations of several persons looking in different directions, Mr. Lawton, of Hull, made the number of meteors to have been 144 per minute for nineteen minutes, from 12:58 to 1:17 A. M.

1867, November 14, A. M. Weather generally unfavorable in England. At St. George, Grenada, there "was observed before daybreak a shower of luminous meteors flying about in every direction and of every conceivable magnitude." At the University Observatory, Toronto, four observers counted 2,287 meteors between midnight and 6 A. M. Of these, 1,345 were seen during the hour from 4 to 5 A. M.

1868, November 14, A. M. Many meteors seen in England, but the sky much overcast. At Rome, Secchi reported that 2,204 meteors were counted between 2:30 A. M. and 5:45 A. M. At Toronto, Canada, 2,886 meteors appeared between November 13, 10:45 P. M., and November 14, 5 A. M.

1869, November 14, A. M. Lieutenant-Colonel Tupman, at Port Said, Lower Egypt, counted 136 meteors between 2:30 A. M. and 5:14 A. M., and they were nearly all Leonids. At Santa Barbara, California, 556 meteors were noted by two observers in 2h. 25m. before 3:45 A. M.

In 1870, moonlight partly interfered, but it was evident the meteor shower had lost its conspicuous character—a fact fully confirmed by observations in 1871. But it had not entirely disappeared, for in the years mentioned, and in those which succeeded, the middle of November always brought some of the swift streak leaving meteors from the well-known radiant in the sickle of Leo.

In 1879 and 1889, on the morning of November 14, very distinct showers of Leonids were observed by the writer at Bristol, and in many other years they were also visible. Mr. Corder, at Bridgewater, saw a few Leonids in 1892, and, in 1893, Prof. Barnard, in California, described them as far more abundant than he had ever seen them before. Many very brilliant ones were seen, and they were especially plentiful on the mornings of November 13, 14 and 15. In 1894 moonlight interfered with observations.

This meteor system evidently forms a complete ellipse, for there seems no reason to doubt that it returns annually without a break. Even in parts of the orbit very far removed from the dense cluster, which seems identical with Tempel's comet (I, 1806), the meteoric particles appear to be pretty numerous distributed, for there were fairly active displays in 1879 and 1888. It is true the shower has not been observed every year, but there is good reason to assume its annual recurrence, and that it would be seen were the nocturnal sky free from clouds and moonlight just at the critical time.

One of the most important features of a meteor shower is that the flights are directed from a common center, and no observation of such a shower can be regarded as complete unless the radiant point has been determined. The writer has generally found the radiant of the Leonids very sharply defined, and it admits of being accurately detected, even by observers who are inexperienced, for the meteors leave luminous streaks, and these, lingering for one or two seconds, enable the directions to be correctly registered. The Leonid radiant has been frequently obtained, and the

following are some of the values given by different observers in various years:

	Dec.	Dec.	
1833, November 13 A. M.	148	+24	Aiken.
" " " "	150	+20	Olunsted.
1836, " " " "	150	+20	G. O. S. New York.
1865, " " " "	148	+23	A. S. Herschel.
" " " "	148	+23	Newton.
" " " "	148	+24	Marsh.
1866, " " 14	149	+23	Mean of nine-
			teen posi-
			tions by the
			best observ-
			ers.
1867, " " " "	147½	+23	Bradley.
" " " "	150½	+23	Watson.
" " " "	148	+23	Harkness.
" " " "	150½	+23½	Sands.
1868, " " " "	152	+18	Gilman.
1869, " " " "	151	+22	Tupman.
1877, " " " "	146	+26	Backhouse.
" " " "	148	+24	Denning.
1879, " " 14-16	147	+23	Perry.
" " " "	151	+22	Sawyer.
" " " "	148	+25	Corder.
" " " "	148	+23	Denning.
1880, " " 12-13	148	+22	Sawyer.
1885, " " 15-18	150	+22	Denning.
1887, " " 15	155	+25	Booth.
" " " "	150	+22	Denning.
1888, " " 14	149	+23	Denning.
1890, " " 14-15	151	+24	Backhouse.

In addition to these, some good positions are given in the catalogues of radiants by various authorities, thus:

	Dec.	Dec.	
November 10-14	148	+22	Schmidt.
" 7-15	153	+22	Greg and Herschel (1863).
" 12-13	148	+24	Heis.
" 11-15	149	+23	Greg (1876).

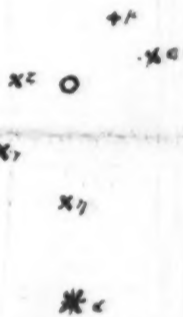
The mean place derived from a large number of positions, agreeing well among themselves and individually fixed by the most trustworthy observers, is at

$$149^{\circ}15' + 22^{\circ}9'.$$

This is almost identical with that of the naked eye star Piazzi IX 230 (mag. 5.7), the place of which in 1880 was

$$149^{\circ}14' + 22^{\circ}5'.$$

Relatively to the bright stars forming the sickle of Leo, the radiant is situated as in the following diagram:



#### PLACE OF THE LEONID RADIANT AMONG THE STARS IN THE SICKLE OF LEO.

It is of no utility beginning a watch for Leonids before 10:30 P. M., as the radiant does not rise until about that time. It is very rarely that a meteor is seen from a radiant on or a little below the horizon, but a remarkable Leonid was observed in 1879, November 13, as early as 10:00 at three different places, viz., Writtle, Bedford and Bristol. As seen from the latter place, the meteor passed through an arc of 90°, the observed path being from 98°+23° to 4°-13°.

The interest in this meteor shower is now rapidly increasing, for we are drawing near the period when brilliant returns may be expected. Two years preceding the maximum, as in 1881 and 1884, we may certainly look for rich displays, so that November, 1897, will form an important epoch. It is also in the highest degree probable that in 1895 and 1896 the shower will give decided indications of returning activity. This year the conditions will be very favorable, as the moon, being a slender crescent and within a few days of the new, will be unable to make her influence felt.

The shower of Leonids certainly endures from November 9 to 17, but the really brilliant displays only last a few hours, and these, at the end of the present century, will occur either on the mornings of the 14th or 15th. 1896 being leap year, the phenomenon may be expected earlier than usual. The year 1898 offers prospective events of extraordinary interest to the meteoric observer, for two brilliant displays may occur within ten days of each other. The Leonids will be due on November 14 and the Andromedes on November 23.

As to the nature of the observations necessary during the progress of a meteor shower, it may be suggested that two persons are required to fully note the features presented. One will record the number of meteors appearing during short intervals, say of five minutes, so that the time of maximum may be ascertained as well as the aggregate number visible during the period covered by the watch. The other will register the individual paths of well-observed meteors on a star chart or celestial globe, determine the place of the radiant and its character, especially note large meteors and any other peculiarities that may offer themselves. One observer, working single-handed, may do a great deal by dividing his attention between the various points alluded to. It is always important to separate the number of meteors visible in a special shower from the total number seen, for the aggregate counted must exceed the actual strength of a particular stream, since it includes the sporadic meteors.

When reckoning the visible meteors, therefore, the observer will do well to keep an account of the number unaccounted for with the radiant of the main display. The radiant of the Leonids can be readily assigned, not only because of the afterflows or phosphorescent streaks left by the meteors, which assist the eye in fixing their exact directions, but also on account of the well known asterism involving it. The Leonids exhibit a more contracted area of radiation than the Andromedes, but it is a feature not yet thoroughly investigated. By selecting a number of well-observed tracks near the radiant, the extent of its diffusion may be readily determined. The writer has sometimes found the center so definite that the conformable paths have intersected at a point.

W. F. DENNING.

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